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(54) Spread spectrum signal generating device and method

(57) There is provided spread spectrum signal generating device and a method in a transmitter of a mobile communications system using a plurality of logical channels. In the spread spectrum signal generating device, a multiplexer time multiplexes a pilot channel signal and a control channel signal which are output at a constant power levels, a first orthogonal encoder orthogonally spreads the output of the multiplexer with an orthogonal code, a second orthogonal encoder orthogonally spreads voice channel data of a variable bit rate with an orthogonal code, a third orthogonal encoder orthogonally spreads packet channel data of a variable bit rate with an orthogonal code, an IQ signal mapper adds the outputs of the first and third orthogonal encoders, outputs the added signal as a first channel signal, and outputs the output of the second orthogonal encoder as a second channel signal and a PN spreader spreads the first and second channel signals with PN codes and outputs a final spectrum spread signal. Therefore, a peak-to-average power ratio of the transmitter is maintained so as to be substantially uniform.

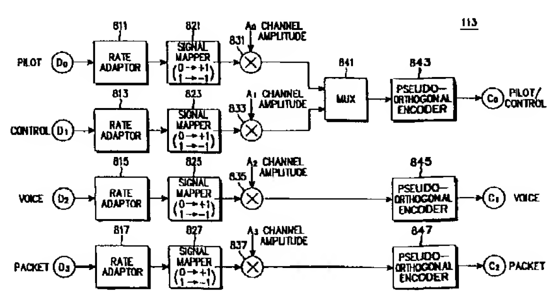

FIG. 8

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Description

[0001] The present invention relates to a spread spectrum signal generating device and method and more particularly to a transmitter and a transmission method in a spread spectrum mobile communications system, and in particular, to a spread spectrum signal generating device and method for managing transmit output levels.

[0002] Along with the deployment of a CDMA (Code Division Multiple Access) mobile communications system, various DSS (Direct Spread Spectrum) transmission and reception schemes have been explored. Coherent demodulation is known to be very effective in increasing the subscriber accommodating capacity of a DSS-CDMA mobile communications system due to a small signal-to-noise ratio required to obtain a given frame error rate, as compared to incoherent demodulation.

[0003] To realise coherent demodulation in a mobile communications environment, the complex gain of a received multipath channel signal of each path should be determined. Complex gains are calculated by a decision directed method or a pilot assisted method. The latter is generally used due to its excellent performance and easy realisation. For details of the pilot assisted method, see "Performance of Adaptive Match Filter Receivers Over Fading Multipath Channels" by Pahlavan and Matthews, IEEE Transactions on Communications, Vol. 38, No. 12, December 1990, pp. 2106-221.

[0004] The pilot assisted method is implemented by parallel probing or serial probing. In parallel probing, a transmitter spreads a spread user data signal, including information and data known to a receiver, with different PN (Pseudo random Noise) sequences. However, data known to the receiver is periodically inserted into the spread user data signal, including information, and then they are spread with the same PN symbol, in serial probing.

[0005] For CDMA mobile radio communications, a user needs to transmit different data such as voice data, control data, and packet data for a high-speed data service or a multimedia service. Two cases should be considered for such data transmission: one is that a small peak-to-average power (PAR) ratio at an output terminal of a terminal leads to a decrease in power dissipation and manufacture cost of the terminal; and the other is that intermittent output of the terminal may cause a device that a user carries to malfunction, such as a hearing aid or a cardiometer. The serial probing is inferior to the parallel probing in terms of intermitted output, but advantageous over the parallel probing in terms of PAR.

[0006] Figure 1 is a block diagram of a transmitter for generating a transmission signal including a pilot signal on a reverse link in a point-to-point spread spectrum CDMA cellular communications system.

[0007] Referring to figure 1, a logical channel data generator 111 has a plurality of data generators for generating channel data and a plurality of scramblers for scrambling the channel data. A channeliser 113 processes the data received from the logical channel data generator 111 in such a manner that interference between channels is small and that the PAR is small. An IQ signal mapper 115 maps the channelised signals received from the channeliser 113 into in-phase and quadrature-phase signals. A PN spreader 117 spreads the output of the IQ signal mapper 115 with PN codes. A baseband modulator 119 translates the spread signal received from the PN spreader 117 to a baseband signal and modulates the baseband signal. A frequency upconverter 121 upconverts the frequency of the modulated signal received from the baseband modulator 119 to a transmission frequency and outputs a radio transmission signal.

[0008] Figure 2A is a block diagram of the logical channel data generator 111 shown in figure 1 and figure 2B is a block diagram of the scramblers shown in figure 2A.

[0009] Referring to figure 2A, the logical channel data generator 111 includes a pilot data generator 211, a control data generator 213, a voice data generator 215, and a packet data generator 217. The pilot data generator 211 outputs unmodulated consecutive 0 bits. Control data generated from the control data generator 213 is composed of a power control command for power control on a forward link or other control information. The voice data generator 215 outputs data from a variable bit rate (VBR) vocoder. The voice data output from the vocoder can be, for example, a convolutionally encoded and interleaved bit sequence. The encoded voice data is output at a VBR of ½, ¼, or 1/8, increasing one bit time by two, four, or eight times. The packet data generator 217 has an output bit rate which is an integer multiple of the highest bit rate 1 to 8 of the voice data generator 215.

[0010] Scramblers 219, 221 and 223 scramble the data received from the control data generator 213, the voice data generator 215, and the packet data generator 217, respectively.

[0011] Referring to figure 2B, a switch 232 of the scramblers 219, 221 or 223 selectively outputs the output of a decimator 233 or data "0", and an exclusive OR gate 231 exclusive-Ors the data received from the data generators 213, 215, or 217 with the output of the decimator 233 or the data "0" selected by the switch 232. The decimator 233 decimates a second PN code sequence (i.e., long PN code sequence) P at the same bit rate as that of the control, voice and packet data, which were all encoded and interleaved.

[0012] Figures 3A and 3B are block diagrams of the channeliser 113 shown in figure 1, differently configured according to the serial and parallel probe methods.

[0013] Referring to figure 3A, rate adaptors 311 to 317, connected to the respective data generators 211 to 217, adjust the data rates of the data generators 211 to 217. Signal mappers 321 to 327, connected to the respective rate

adaptors 311 to 317, convert bits 0s and 1s of rate-adapted data to +1s and -1s, respectively. Multipliers 331 to 337 multiply converted signals received from the signal mappers 321 to 327 by corresponding channel amplitude control signals A0 to A3. A multiplexer 341 multiplexes the outputs of the multipliers 331 to 337.

[0014] In the channeliser 113 using the serial probe scheme, each data is time multiplexed to an output C_o, to occupy a different time slot and the time that the data occupies is adjusted by varying the number of repetitions of the outputs of the data generators 211 to 217 in the rate-adaptors 311 to 317. The rate-adapted data is converted from logical channel data 0s and 1s to +1s and -1s suitable for transmission by the signal converters 321 to 327 and multiplied by the channel amplitude control signals A0 to A3 by the multipliers 331 to 337, thereby determining power levels.

[0015] Referring to figure 3B, rate adaptors 351 to 357 are connected to the data generators 211 to 217 of the logical channel data generator 111 and adjust data transmission rates of the corresponding data generators 211 to 217. Signal mappers 361 to 367 are connected to the corresponding rate adaptors 351 to 357, for converting bits 0s and 1s of rate-adapted data to +1s and -1s, respectively. Walsh c code generators 371 to 377 generate Walsh codes WO to W3. Multipliers 381 to 387 multiply signals received from the signal mappers 321 to 327 by the Walsh codes W0 to W3 received from the Walsh code generators 371 to 377 to reduce or remove interference between channels and phase errors. Thus, the Walsh code generators 371 to 377 and the multipliers 381 to 387 serve as an interference remover. Multipliers 391 to 397 multiply the outputs of the multipliers 381 to 387 by the corresponding channel amplitude control signals A0 to A3 acting as a channel amplitude controller.

[0016] In the channeliser 113 using the parallel probe method, the occupation time of each data is adjusted by varying the number of repetitions of the outputs of the data generators 211 to 217 by the rate adaptors 351 to 357. The rate-adapted data is converted from logical channel data 0s and 1s to +1s and -1s suitable for transmission by the signal mappers 321 to 217, and multiplied by the mutually orthogonal Walsh codes by the multipliers 381 to 387 thereby reducing interference between channels and phase error-induced performance deterioration. The outputs of the multipliers 381 to 387 are multiplied by the corresponding channel amplitude control signals A0 to A3 by multipliers 391 to 397 so that power levels are controlled.

[0017] Figure 4A is a block diagram of the IQ signal mapper 115 shown in figure 1, which is connected to the channeliser 113 for the serial probe scheme, and figure 4B is a block diagram of the IQ signal mapper 115 shown in figure 1, which is connected to the channeliser 113 for the parallel probe scheme. The IQ signal mapper 115 maps a channelised signal into in-phase and quadrature-phase signals.

[0018] As the final output C_o of the channeliser 113 using the serial probe scheme is multiplexed data, the IQ signal mapper 115 of figure 4 is provided with a serial-to-parallel converter 411 for separating the multiplexed signal into odd-numbered bits and even-numbered bits and generating an in-phase signal (I signal) and a quadrature-phase signal (Q signal).

[0019] Since the final output of the channeliser 113 using the parallel probe scheme is non-multiplexed parallel data, the IQ signal mapper 115 of figure 4B has an adder 421 for adding the pilot channel signal C_o and the voice channel signal C_2 and thus generating an I signal, and an adder 423 for adding the control channel signal C_1 and the packet channel signal C_1 and thus generating a Q signal.

[0020] Figure 5A is a block diagram of the PN spreader 117 shown in figure 1 using an IQ split method, and figure 5B is a block diagram of a PN spreader 117 shown in figure 1 using a complex spreading method. Here, a first PN code refers to a short PN code, and a second PN code refers to a long PN code, see for example, IS-IT 5 standard reverse link spreading.

[0021] Referring to figure 5A, a first Pni code generator 511 generates an in-phase PN code, Pni, and a first PNq code generator 513 generates a quadrature-phase PN code, PNq. A second PN code generator 515 generates a long PN code commonly applied to the in-phase PN code, Pni and the quadrature-phase PN code, PNq. A multiplier 571 multiplies PNi by the second PN code thereby generating an in-phase PN code. A multiplier 519 multiplies PNq by the second PN code, thereby generating a quadrature-phase PN code. A multiplier 520 multiplies the I signal received from the IQ signal mapper 115 by the quadrature-phase PN code and generates a spread signal PI. A multiplier 512 multiplies the Q signal received from the IQ signal mapper 115 by the in-phase PN code and generates a spread signal PQ.

[0022] Mow, there will be given a description of the PN spreader 117 for complex spreading shown in figure 5B. Referring to figure 5B, the first PNi code generator 511 generates the in-phase PN code, PNi, and the first PNq code generator 513 generates a quadrature-phase PN code PNq. The second PN code generator 515 generates a long PN code commonly applied to both of the PN codes PNi and PNq. The multiplier 517 multiplies PNi by the second PN code thereby generating an in-phase PN code. The multiplier 519 multiplies PNq by the second PN code thereby generating a quadrature-phase PN code. A multiplier 521 multiplies the I signal received from the IQ signal mapper 115 by the in-phase PN code. A multiplier 523 multiplies the Q signal received from the IQ signal mapper 115 by the in-phase PN code. A multiplier 525 multiplies the Q signal received from the IQ signal mapper 115 by the quadrature-phase PN code. A multiplier 527 multiplies the I signal received from the IQ signal mapper 115 by the quadrature-phase PN code. A subtracter 529 subtracts the output of the multiplier 525 from the output of the multiplier 521 and generates a complex-spread in-phase signal PI. An adder 531 adds the outputs of the multipliers 523 and 527 and generates a complex-

spread quadrature-phase signal PQ.

[0023] The PN spreader 117 of figure 5B is advantageous over that figure 5A in terms of peak-to-average power ratio.

[0024] The baseband modulator 119 configured as shown in figure 6 modulates the spread signals PI and PQ received from the PN spreader 117 shown in figure 5A or 5B. Referring to figure 6, the spread signal PI is filtered by an FIR (Finite Impulse Response) filter 615 whereas the spread signal PQ is delayed by a predetermined time in a delay 611 and filtered by an FIR filter 613. The baseband modulator 119 may operate based on OQAM (offset Quadrature Amplitude Modulation).

[0025] A transmitter using the parallel probe method includes the channeliser 113 of figure 3B, the IQ signal mapper 115 of figure 4B, the PN spreader 117 of figure 5B and the baseband modulator 119 of figure 6. On the other hand, a transmitter using the serial probe method has the channeliser 113 of figure 3A, the IQ signal mapper 115 of figure 4A, the PN spreader 117 of figure 5A, and the baseband modulator 119 of figure 6.

[0026] The transmitter using the parallel probe method increases PAR, and that of the serial probe method suffers a significant power variation due to a varied bit rate of a voice signal and the intermittent presence of a packet signal, thereby increasing interference.

[0027] Therefore, concurrent use of multiple channels gives rise to problems associated with an amplifier in the conventional transmitters. That is, because the pilot channel, the control channel, the voice channel, and the packet channel are simultaneously used, a peak-to-average power ratio is increased, which implies that the amplifier should exhibit an excellent linearity. In particular, a terminal using only the voice channel (i.e. low speed traffic channel) without the packet channel (i.e. high speed traffic channel) may have a significantly increased peak-to-average power ratio depending on gain adjustment for channels.

[0028] Accordingly, a first of the present invention provides a spread spectrum signal generating device for a transmitter of a mobile communication system using a plurality of channels comprising at least one of either constant bit rate and constant power level signals and at least one of either variable bit rate and variable power level signals, the device comprising: means for producing and outputting a time multiplexed channel by time multiplexing only the constant bit rate and constant power level signals for output on a first channel; and means for outputting at least one of the variable bit rate and variable power level signals on a second channel which is independent of the first channel.

[0029] Preferably, there is provided a device further comprising encoders for orthogonally spreading the first channel and the second channel using respective orthogonal codes.

[0030] An embodiment provides a device wherein the plurality of channels comprises a pilot channel signal, a control channel signal, a voice channel signal and a packet channel signal, and wherein means for producing a time multiplexed channel comprises: a multiplexer for time multiplexng the pilot channel signal and the control channel signal; a first orthogonal encoder for orthogonally spreading the output of the multiplexer using an orthogonal code; a second orthogonal encoder for orthogonally spreading the voice channel signal having a variable bit rate using an orthogonal code; a third orthogonal encoder for orthogonally spreading the packet channel signal having a variable bit rate using an orthogonal code; an IQ signal mapper for adding the outputs of the first and third orthogonal encoders, outputting the added signal on the first channel and outputting the output of the second orthogonal encoder on the second channel.

[0031] Preferably, the IQ mapper further comprises means for outputting the output of the second orthogonal encoder on the second channel in the presence of a voice channel signal; and means for outputting the outputs of the first and third orthogonal encoders on the first channel and the second channel respectively in the absence of a voice channel signal.

[0032] Still more preferably, en embodiment provides a device further comprising a PN spreader for spreading the first and second channels using PN codes to produce a spread spectrum signal; and means for outputting the spread spectrum signal.

[0033] Preferably, the PN spreader comprises means for complex-multiplying the first and second channels using PN codes.

[0034] A preferred embodiment provides a device further comprising a baseband modulator for baseband filtering the output of the PN spreader and modulating the filtered signal.; and/or a frequency converter for upconverting the frequency of the output of the baseband modulator to a transmission frequency.

[0035] A preferred embodiment provides a device wherein the means for producing and outputting a time multiplexed channel comprises a plurality of rate adaptors for adjusting the rates of the at least one of either constant bit rate and constant power level signals and at least one of either variable bit rate and variable power level signals; a plurality of signal mappers for converting the 0s and 1s received from the rate adaptors into +1s and -1s respectively; a plurality of channel amplitude controllers for multiplying the outputs of the signal mappers by corresponding channel amplitude control values.

[0036] Still more preferably, an embodiment provides a device wherein the orthogonal codes comprises multipath resistant pseudo codes (MRPOCs) such as are described in the appendix.

[0037] A second aspect of the present invention provides a spread spectrum signal generating method for a transmit-

ter of a mobile communication system using a plurality of channels comprising at least one of either constant bit rate and constant power level signals and at least one of either variable bit rate and variable power level signals, the method comprising the steps of producing and outputting a time multiplexed channel by time multiplexing only the constant bit rate and constant power level signals for output on a first channel; and outputting at least one of the variable bit rate and variable power level signals on a second channel which is independent of the first channel.

[0038] A preferred embodiment provides a method further comprising the step of orthogonally spreading the first channel and the second channel using respective orthogonal codes.

[0039] Preferably, a method is provided wherein the plurality of channels comprises a pilot channel signal, a control channel signal, a voice channel signal and a packet channel signal, and wherein the step of producing a time multiplexed channel comprises the steps of time multiplexng the pilot channel signal and the control channel signal; orthogonally spreading, using a first orthogonal encoder, the output of the multiplexer using an orthogonal code; orthogonally spreading, using a second orthogonal encoder, the voice channel signal having a variable bit rate using an orthogonal code; orthogonally spreading, using a third orthogonal encoder, the packet channel signal having a variable bit rate using an orthogonal code; and adding the outputs of the first and third orthogonal encoders, outputting the added signal on the first channel and outputting the output of the second orthogonal encoder on the second channel.

[0040] An embodiment preferably provides a method further comprising the steps of outputting the output of the second orthogonal encoder on the second channel in the presence of a voice channel signal; and outputting the outputs of the first and third orthogonal encoders on the first channel and the second channel respectively in the absence of a voice channel signal.

[0041] Preferably, there is provided a method further comprising the steps of spreading, using a PN spreader, the first and second channels using PN codes to produce a spread spectrum signal; and outputting the spread spectrum signal.

[0042] An embodiment of the present invention provides a method wherein the step of spreading comprises the step complex-multiplying the first and second channels using PN codes.

[0043] Preferably, a method provides a method further comprising the steps of baseband filtering, using a baseband modulator, the output of the PN spreader; and modulating the filtered signal.

[0044] A preferred embodiment provides a method further comprising the step of upconverting, using a frequency converter, the frequency of the output of the baseband modulator to a transmission frequency.

[0045] Preferably, there is provided a method wherein the step of producing and outputting a time multiplexed channel comprises the steps of adjusting, using a plurality of rate adaptors, the rates of the at least one of either constant bit rate and constant power level signals and at least one of either variable bit rate and variable power level signals; converting, using a plurality of signal mappers, the 0s and 1s received from the rate adaptors into +1s and -1s respectively; multiplying, using a plurality of channel amplitude controller, the outputs of the signal mappers by corresponding channel amplitude control values.

[0046] Preferably, an embodiment provides a method wherein the orthogonal codes comprises multipath resistant pseudo codes (MRPOCs).

[0047] Embodiments of the present invention advantageously provide a spread spectrum signal generating device and method in a mobile communications system for transmitting data of multiple logical channels, where the data of logical channels having constant transmit power levels is channelised by multiplexing and orthogonal codes.

[0048] Embodiments facilitate the provision a spread spectrum signal generating device in a mobile communications system for transmitting data of multiple logical channels, where the data of logical channels having a constant transmit power levels is channelised by multiplexing and the data of the other logical channels is channelised on the basis of the power level of the multiplexed channel.

[0049] An embodiment provides a spread spectrum signal generating device in a transmitter of a mobile communications system using a plurality of logical channels. In the spread spectrum signal generating device, a multiplexer time multiplexes a pilot channel signal and a control channel signal which are output at constant power levels, a first orthogonal encoder orthogonally spreads the output of the multiplexer with an orthogonal code, a second orthogonal encoder orthogonally spreads voice channel data of a variable bit rate with an orthogonal code, a third orthogonal encoder orthogonally spreads packet channel data of a variable bit rate with an orthogonal code, an IQ signal mapper adds the outputs of the first and third orthogonal encoders, outputs the added signal as a first channel signal, and outputs the output of the second orthogonal encoder as a second channel signal, and a PN spreader spreads the first and second channel signals with PN codes and outputs a final spectrum spread signal. Therefore, a peak-to-average power ratio of the transmitter is maintained at a substantially uniform level.

[0050] Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings in which:

figure 1 is a block diagram of a spread spectrum transmitter in a mobile communications system;
figure 2A is a block diagram of a logical channel data generator shown in figure 1;
figure 2B is a block diagram of scramblers shown in figure 2A;

figures 3A and 3B are block diagrams of a channeliser shown in figure 1;
figures 4A and 4B are block diagrams of an IQ signal mapper shown in figure 1;
figures 5A and 5B are block diagrams of a PN spreader shown in figure 1;
figure 6 is a block diagram of a baseband modulator shown in figure 1;
figure 7A is a block diagram of a logical channel data generator according to an embodiment of the present invention;
figure 7B is a block diagram of scramblers shown in figure 7A;
figure 8 is a block diagram of a channeliser according to an embodiment of the present invention;
figure 9 illustrates output characteristics of the channeliser according to an embodiment of the present invention; and
figures 10A and 10B are block diagrams of an IQ signal mapper according to an embodiment of the present invention.

[0051] Simultaneous transmission of pilot data, control data, voice data, and packet data increases a peak-to-average power ratio in a mobile communications system for transmitting data of multiple logical channels. This may cause problems in the linearity of a power amplifier of a transmitter. The peak-to-average power ratio and the number of orthogonal codes used for channelisation can be reduced by channelising a pilot signal and a data signal through time multiplexing.

[0052] If there exist only pilot data, control data, and the voice data has the highest bit rate in a transmitter using the parallel probe method, the power ratio of pilot channel: control channel: voice channel is 1:1/4:4 and a peak-to-average power ratio at an output terminal is 6.95dB. In addition, with voice data having a bit rate of one eighth of the highest bit rate, the power ratio becomes 1:1/4:1/2 and the peak-to-average power ratio is 7.23dB. Here, the average energy ratio per unit time of the pilot channel to the control channel is fixed at 1:1/4. However, since the voice channel has a variable bit rate, it has 4-1/2 times the average energy of the pilot channel. The peak-to-average power ratio increases as the difference in energy between channels which are added in the IQ signal mapper 115 reduces.

[0053] In an embodiment of the present invention relying on the above principles, the logical channel data generator 111 is configured as shown in figures 7A and 7B, and the channeliser 113 is constituted as shown in figure 8 so that the power level of the multiplexed pilot/control channel is et to be the sum of the power level of the pilot channel and the power level of the control channel in parallel probing. For example, if the power level of the pilot channel is 1 and that of the control channel is ¼ in parallel probing then the power level of the time multiplexed pilot/control channel is 1+¼. The control channel is output for 4/5 time as shown in figure 9.

[0054] Figure 7A is a block diagram of the logical channel data generator 111 according to an embodiment of the present invention, and figure 7B is a block diagram of scramblers shown in figure 7A.

[0055] Referring to figure 7A, the logical channel data generator 111 includes a pilot data generator 711, a control data generator 713, a voice data generator 715, and a packet data generator 717. The pilot data generator 711 outputs unmodulated consecutive bits 0s. Control data generated from the control data generator 713 comprises a power control command for power control on a forward link or other control information. The voice data generator 715 outputs data from a vocoder at a variable bit rate. The voice data output from the vocoder can be, for example, a convolutionally encoded and interleaved bit sequence. The encoded voice data is output at a VBR of 1/2, 1/4, or 1/8, increasing one bit time by two, four, or eight times. The packet data generator 717 has an output bit rate which is an integer multiple of the highest bit rate 1 to 8 of the voice data generator 215. Scramblers 721 to 727 scramble the data received from the data generators 711 to 717.

[0056] Referring to figure 7B, a decimator 733 of the scrambler 721 to 727 decimates according to a predetermined value P, and an exclusive OR gate 731 exclusive Ors the output of the data generators 711 to 717 with the output of the decimator 733. The pilot data, control data, voice data, and packet data are all encoded and interleaved. The interleaved data is exclusive ORed with the data resulting from decimating a second PN code sequence at the same bit rate as that of the interleaved data. Figure 8 is a block diagram of the channeliser 113 according to the embodiment of the present invention. Referring to figure 8, rate adaptors 811 to 817 are connected to the corresponding data generators 711 to 717, for adjusting the data transmission rates of the data generators 711 to 717. Signal mappers 821 to 827 are connected to the rate adaptors 811 to 817, for converting bits, 0s and 1s, of the rate-adapted data to + 1s and - 1s, respectively. Multipliers 831 to 837 multiply the outputs of the signal mappers 821 to 827 by the corresponding channel amplitude control signals A0 to A3. A multiplexer 841 multiplexes the outputs of the multipliers 831 and 832. The multiplexed signal is a pilot/control channel signal. A pseudo-orthogonal encoder 842 spreads the pilot/control channel signal with a multipath resistant pseudo-orthogonal code (MRPOC) to overcome the problem or orthogonality loss caused by a multipath signal component. A pseudo-orthogonal encoder 845 spreads the voice data channel signal with an MRPOC, and a pseudo-orthogonal encoder 847 spreads the packet data channel signal with an MRPOC. MRPOCs are described in the appendix and are the subject of co-pending application reference P71033EP. In realising the channeliser 113 of figure 8, if E and F are the corresponding channel gains in the conventional parallel probe, the gains A_0 and A_1 in this invention have identical values computed from E and F by equations (1) and the pilot and control channels

are output for the time periods calculated by equations (2) and (3), respectively.

$$A_0 = \sqrt{E^2 + F^2},\ A_1 = \sqrt{E^2 + F^2} \tag{1}$$

$$\frac{E^2}{E^2 + F^2} \tag{2}$$

$$\frac{F^2}{E^2 + F^2} \tag{3}$$

[0057] Therefore, the multiplexer 841 of figure 8 multiplexes the pilot and control channel signals to a signal C_0 as shown in figure 9, and the voice and packet data channel signals are output without being multiplexed. The output of the multiplexer 841, the voice data signal, and the packet data signal are spread by the pseudo-orthogonal encoders 843 to 847 thereby ensuring orthogonality which would otherwise be lost due to a multipath propagated component.

[0058] When the voice channel transmits power, that is, in the presence of voice data, the voice channel signal is output as a Q channel signal, as shown in figure 10A, and the packet/control channel signal is added to the packet data signal by an adder and output as an I channel signal. In the absence of voice data, the packet signal is output as a Q channel signal and the packet/control signal is output as an I channel signal, as shown in figure 10B. When power is transmitted from the voice channel output from the channeliser 113, the IQ signal mapper 115 outputs the voice channel signal in using a phase which is different to that of the pilot/control channel and adds the packet data and the pilot/control channel signal to the other output, as shown in figure 10A. If the voice channel is off, the packet channel signal is output using a phase which is different to that if the pilot/control channel signal, as shown in figure 10B.

[0059] The PN spreader 117 in the embodiment of the present invention may be configured as shown in figure 5B and reduces a peak-to-average power ratio. Preferably, the modulation follows the method of figure 6 In this case, the peak-to-average power ratio is smaller than that in a general parallel probe method by between 1.5-1.9dB.

[0060] The Walsh encoders of figure 3B or inner codes of a pseudo-orthogonal code can be used for the pseudo-orthogonal encoders 843 to 847 of figure 8. Preferably a PN sequence should be generated to have an appropriate bit rate in a PN code generator. Since pilot data is always uniform, use of the pseudo-orthogonal codes may cause interference to other users. To prevent this, the pilot data is scrambled by a scrambling sequence decimated from the second PN code generator.

[0061] As described above, a pilot signal and a data signal are channelised through time multiplexing in a mobile communications system using a plurality of logical channels such as pilot data, control data, voice data and packet data thereby reducing a peak-to-average power ration and the number of orthogonal codes involved in channelisation.

[0062] While the present invention has been described in detail with reference to the specific embodiment, it is a mere exemplary application. Thus, it is to be clearly understood that many variations can be made by anyone skilled in the art within the scope and spirit of the present invention.

APPENDIX

PSEUDO-ORTHOGONAL CODE GENERATING METHOD AND DEVICE

The present invention relates to a pseudo-orthogonal code generating method and device and to a spread spectrum device and method for a CDMA (Code Division Multiple Access) mobile communications system, and in particular, to a device and method for generating a spread spectrum signal using a pseudo-orthogonal code.

In a CDMA mobile communications system, a communication is conducted within a given frequency bandwidth shared by multiple users which have been assigned differential codes. A data transmission rate for a user is generally very low relative to the frequency bandwidth. In order to transmit a low-rate data within the high-rate frequency bandwidth, spread spectrum codes are used for discriminating users. Hence, low-rate data bit sequences are spread with a high-rate spreading code to be transmitted/received within the given frequency bandwidth.

An orthogonal code spreading scheme using Walsh codes can be employed in a CDMA mobile communications system for discrimination of users and spectrum spreading. The orthogonality of the Walsh codes enables users or channels to be discriminated without interference in an ideal case.

Figure 1 is a block diagram of a conventional spread spectrum signal generating device using Walsh codes.

Referring to figure 1, a signal mapper 111 changes 0s and 1s of an input data bit sequence to +1s and -1s, respectively. An orthogonal code spreading and PN masking portion 117 spreads the signal values +1s and -1s at a high rate. Specifically, the orthogonal code spreading and PN (Pseudo random Noise) masking portion 117 orthogonally spreads the signal received from the signal mapper 111 with an assigned Walsh code Wi and then performs a PN masking on the spread signal using PN codes, that is, PNi and PNq to discriminate

base stations or users. Then, the PN-masked signal is baseband-pass filtered by a baseband filter 119 and converted to a radio signal by a frequency shifter 121.

Figures 2A, 2B and 2C are examples of the orthogonal code spreading and PN masking portion 117 shown in figure 1. Figure 2A is a first example of the orthogonal code spreading and PN masking portion 117 of a conventional IS-95 CDMA mobile communications system. Referring to figure 2A, a multiplier 211 multiplies an input signal of +1 or -1 by an assigned Walsh code Wi, for orthogonal spreading. The spread signal is separated into a real part and an imaginary part and applied to multipliers 212 and 213, respectively. Then, the multipliers 212 and 213 multiply the respective spread signals using a pair of PN codes, that is, PNi and PNq for PN masking.

Figure 2B illustrates a second example of an orthogonal code spreading and PN masking portion 117 for doubling the number of available Walsh codes. Referring to figure 2B, a serial-to-parallel converter 221 separately outputs odd numbered and even numbered signals of +1 or -1. Then, multipliers 222 and 223 multiply the odd-numbered signal and the even-numbered signal by the Walsh code Wi, respectively. For PN masking, a multiplier 224 multiplies the output of the multiplier 222 by a PN code, PNi and a multiplier 225 multiplies the output of the multiplier 223 by a PN code, PNq. Since the transmission rate of a +1 or a -1 signal in the directions of a real and imaginary parts is half of that of the input in this method, the length of the Walsh code should be doubled. Thus, the number of available Walsh codes is increased by a factor of two.

Figure 2C is a third example of an orthogonal code spreading and PN masking portion 117 shown in figure 1 in which the number of available Walsh codes is doubled as for the structure of figure 2 and PN masking is performed through complex spreading to thereby make the signal strengths of the real and imaginary parts equal. Referring to figure 2C the

serial-to-parallel converter 231 separately outputs odd-numbered and even-numbered signals of +1s or -1s. Then, the multipliers 232 and 233 multiply the odd-numbered signal and the even-numbered signal by the Walsh code Wi, respectively, to produce outputs di and dq. A complex multiplier 234 multiplies di and dq by PNi and PNq, respectively and outputs PN-masked signals, Xi and Xq. Here, the complex multiplier 234 operates as follows:

$$(Xi+jXq) = (di+jdq) * (Pni+jPNq).....(1)$$

The method shown in figure 2C enables a signal to be recovered without interference because a Walsh code used in generating a spread spectrum signal shows a correlation value of 0 with respect to another Walsh code under an ideal condition (i.e. single path propagation).

Figures 3A and 3B are graphs of correlation characteristics of Walsh codes. Figure 3A illustrates the relationship between signal delay and auto-correlation and figure 3B illustrates the relationship between signal delay and cross-correlation.

In the case of auto-correlation as shown in figure 3A a spread spectrum signal generated in the orthogonal code spreading and PN masking portions 117 of figures 2A, 2B and 2C is recovered with a strength equal to the length N of a Walsh code in code synchronisation, but its correlation value is not 0 but 1 in code misalignment by one or more chips. In the case of cross-correlation as shown in figure 3B when two Walsh codes are synchronised, there is no interference, but in code misalignment by one or more chips, a 1-interference signal appears, that is, an interference signal having a strength of 1/N relative to that of the original signal.

The influence of the interference signal is inversely proportional to the length N of the Walsh code. If a signal is received by at least two paths and one or more chip-delay exists between the paths, the orthogonality of the Walsh code

is lost and an interference is generated due to a delayed signal.

Furthermore, an issue exists as to define one or more chip-delay time in the above situation. A high rate data service typically requires, a frequency bandwidth, which implies that the duration of a single chip progressively becomes less with increasing frequency or data rate. The duration of one chip is generally

$$T_c = \frac{I}{BW} \quad ....(2)$$

Where T_c is the duration of one chip and BW is an available frequency bandwidth. As noted from equation (2), as BW doubles, T_c decreases by half. Hence, a signal, which is transmitted via a single path in a voice only service, may exhibit a multipath propagation characteristic, that is, time delay of at least one chip duration when an available frequency bandwidth is widened for a high-speed data service. In this case, the orthogonality of a Walsh code may be lost.

Accordingly, a first aspect of the present invention provides a pseudo-orthogonal code generating method for spreading input channel data in a CDMA communication system, the method comprising the steps of selecting M orthogonal codes from N orthogonal codes for forming a pseudo-orthogonal code; and interlacing the elements of the selected M orthogonal codes to generate the pseudo orthogonal code as a sequence of MxN elements.

Advantageously, the present invention facilitates the provision of a high-quality, high-speed data service over a CDMA mobile communications network.

It will be appreciated that the orthogonality of a signal transmitted on a multipath propagation channel is maintained by compensating for the delay time of the signal.

Further, the present invention advantageously prevents or reduces loss of the orthogonality of a spreading code caused

by a multipath signal component by spreading data with a multipath resistant pseudo orthogonal code (MRPOC).

A second aspect of the present invention provides A pseudo-orthogonal code generating device for spreading channel data in a CDMA communication system, the device comprising means for selecting M orthogonal codes from N orthogonal codes for forming a pseudo-orthogonal code; and means for interlacing the elements of the selected M orthogonal codes to generate the pseudo orthogonal code as a sequence of MxN elements.

A third aspect of the present invention provides a spread spectrum method using a pseudo-orthogonal code in a CDMA communication system, the method comprising the steps of converting, using a signal converter, at least one input channel data bit stream into a converted signal; generating a pseudo-orthogonal code which is a combination of M different orthogonal codes using a pseudo-orthogonal code generating method, generating, using a PN code generator, a PN code comprising real and imaginary component parts; pseudo-orthogonal code spreading and PN masking, using a pseudo-orthogonal code spreading and masking portion, by dividing the converted signal into M signal sequences, multiplying each signal sequence by the pseudo-orthogonal code, generating MxN sequences; and multiplying each spread signal sequence by a PN code for PN masking; and baseband filtering, using a baseband filter, the output of the pseudo-orthogonal code spreading and masking portion to produce a filtered signal; and shifting, using a frequency shifter, the frequency of the filtered signal.

A fourth aspect of the present invention provides a spread spectrum device using a pseudo-orthogonal code in a CDMA communication system, the device comprising a signal converter for converting an input channel data bit stream into a converted signal; a pseudo-orthogonal code generator for generating a pseudo-orthogonal code which is a combination of M different orthogonal codes using a pseudo-orthogonal code generating device, a PN code generator for

generating a PN code comprising real and imaginary component parts; a pseudo-orthogonal code spreading and masking portion for dividing the converted signal into M signal sequences, multiplying each signal sequence by the pseudo-orthogonal code, generating MxN sequences; and multiplying each spread signal sequence by a PN code for PN masking; and a baseband filter for baseband filtering the output of the pseudo-orthogonal code spreading and masking portion to produce a filtered signal; and a frequency shifter for shifting the frequency of the filtered signal.

An embodiment of the present invention provides a pseudo-orthogonal code generating method, and device, for use in orthogonally spreading channel data in a CDMA mobile communication system. In the method, M orthogonal codes are selected from N orthogonal codes for forming a pseudo-orthogonal code, and the elements of the M orthogonal codes are sequentially interlaced to generate the pseudo-orthogonal as a sequence of MxN elements.

According to another aspect of the present invention there is provided a device for orthogonally spreading channel data in a CDMA mobile communication system. In the device, a pseudo-orthogonal code generator has a table for storing M orthogonal codes, which are selected from N orthogonal codes to form pseudo-orthogonal codes in the form of index pairs and which generates a pseudo-orthogonal code as a sequence of MxN elements by sequentially interlacing the elements of the M orthogonal codes in an index pair corresponding to an input code index. A multiplexer multiplexes input channel data to M-branch parallel data, a plurality of spreaders spreads the multiplexed M-branch data with M corresponding orthogonal codes by multiplication and a demultiplexer demultiplexes the parallel spread data to produce serial data.

Embodiments of the present invention will now be described, by way if example only, with reference to the accompanying drawings in which:

Figure 1 is a block diagram of a conventional spread spectrum signal generating device using a Walsh code in a CDMA mobile communications system;

Figures 2A, 2B and 2C are block diagrams of examples of the orthogonal code spreading and PN masking portion shown in FIG 1;

Figures 3A and 3B are graphs showing correlation characteristics of a general Walsh code;

Figure 4 is a block diagram of a spread spectrum signal generating device using an MRPOC in a CDMA mobile communications system according to an embodiment of the present invention;

Figures 5A, 5B and 5C are block diagrams of an MRPOC spreading and PN masking portion as shown in figure 4;

Figure 6 is a timing diagram of a combination of Walsh codes for maintaining an orthogonality against one chip-delay and a one-bit delayed combination of Walsh codes;

Figures 7A and 7B are graphs showing correlation characteristics of a pseudo-orthogonal code derived from Walsh codes;

Figure 8 is a block diagram of a spreader using a pseudo-orthogonal code;

Figure 9 is a block diagram of a transmitter using the pseudo-orthogonal code for a reverse link;

Figure 10 is a block diagram of a pseudo-orthogonal code spreading and PN masking portion for a reverse link, in which pseudo-orthogonal codes are applied to a pilot/control channel and a traffic channel and PN masking is performed by complex spreading;

Figure 11 is a block diagram of a pseudo-orthogonal code spreading and PN masking portion for a reverse link, in which

pseudo-orthogonal codes are applied to both the pilot/control channel and traffic channel and PN masking is not performed by complex spreading;

Figure 12 is a block diagram of a pseudo-orthogonal code spreading and PN masking portion for a reverse link, in which a pseudo-orthogonal code is applied to only the traffic channel and PN masking is not performed by complex spreading;

Figure 13 is a block diagram of a pseudo-orthogonal code spreading and PN masking portion for a reverse link, in which the traffic channel is separated into odd-numbered bits and even-numbered bits, pseudo-orthogonal codes are applied to the odd-numbered and even-numbered bits, respectively, and PN masking is not performed by complex spreading; and

Figure 14 is a block diagram of a pseudo-orthogonal code spreading and PN masking portion for a reverse link, in which the traffic channel is separated into odd-numbered bits and even-numbered bits, pseudo-orthogonal codes are applied to the odd-numbered and even-numbered bits, respectively, and PN masking is performed by complex spreading.

In orthogonal spreading with a Walsh code, a signal transmitted on a single path propagation channel can have an improved signal-to-noise ratio since the single path propagation channel is free of an interference signal caused by another Walsh code. However, in the presence of at least two paths having a signal arrival time difference of one or more chips, a signal suffers interference from both its own Walsh code and a different Walsh code assigned to another user, thereby losing the benefit of using the Walsh code. Therefore, if there is no interference signal despite a time delay of one or more chips, or interference involved in the existing Walsh codes can be remarkably reduced, the signal-to-noise ratio of a signal transmitted on a multipath propagation channel may be improved as compared to use of the Walsh codes. In an embodiment, an orthogonal code capable of reducing interference caused by a one or more chip-delay is referred to as a multipath resistant pseudo-orthogonal code

(MRPOC). In addition, an MRPOC for reducing interference effects imposed by a one-chip delay is called a one-chip resistant pseudo-orthogonal code, and an MRPOC for reducing interference effects imposed by an m-chip delay is called an m-chip resistant pseudo-orthogonal code.

Although Walsh codes are useless for a reverse link due to the difference in path delay time of signals from terminals to a base station in IS-95, a pseudo-orthogonal code capable of minimising, reducing, preferably an interference signal despite a time of one or more chips can be advantageously used on the reverse link with minimum, reduced, preferably time alignment. Thus, there is a need for exploring such a pseudo orthogonal code and constituting a link using the same.

Given an MRPOC, a spread spectrum signal generating method using the code can be realised. Figure 4 is a block diagram of a spread spectrum signal generating device using the MRPOC according to an embodiment of the present invention.

Referring to figure 4, a signal mapper 411 changes 0s and 1s of an input data bit stream to +1s and -1s, respectively. An MRPOC generator 413 generates an MRPOC Ci assigned by the code index of a corresponding channel. A PN code generator 415 generates a pair of PN codes, PNi for a real part and PNq for an imaginary part. An MRPOC spreading and PN masking portion 417 multiplies the signal received from the signal mapper 411 by the MRPOC Ci and then by PNi and PNq for PN masking, and generates signals Xi and Xq. A baseband filter 419 baseband-pass filters the signals Xi and Xq and a frequency shifter 421 shifts the signal received from the baseband filter 419 to an RF (Radio Frequency) signal.

In figure 4, the MRPOC generator 413, the MRPOC spreading and PN masking portion 417, and the PN code generator 415 are spreading portions, and it is assumed that data is transmitted on an ith channel.

Referring to figure 4, the MRPOC generator 413 has a table for storing MRPOCs and selectively outputs an MRPOC corresponding to a code index. The table stores index pairs of orthogonal codes. Here, the index pair refers to a pair of index codes for different orthogonal codes. Therefore, a one-chip resistant pseudo-orthogonal code is a pair of two different orthogonal codes, a two-chip resistant pseudo-orthogonal code is a combination of three different orthogonal codes, and an (m-1) chip resistant pseudo-orthogonal code is a combination of m different orthogonal codes. The code index indicates an address point value in the table.

For a description of an MRPOC Ci generating procedure in the MRPOC generator 413, it is assumed that the number of orthogonal codes in N and the MRPOC Ci is generated using M orthogonal codes. Here, M is smaller than N and Ci = {W1...WM}. That is the MRPOC Ci is obtained by deriving a fractional set A with M elements (n(A)=M) from an orthogonal code set W={W1....WN}. The elements in the set A are different codes. Index pairs in the MRPOC generator 413 can be listed from orthogonal codes, as follows.

(Table 1)

code index	index pair
1	W0 W20
2	W2 W35
3	W3 W63
4	W4 W11
5	W5 W47
6	W6 W9
=	=
=	=
=	=

Orthogonal codes for MRPOC are used only once and the orthogonal code pairs can be designated by test.

When a code index is generated, the orthogonal codes corresponding to the code index are selected. Then, the elements of the selected orthogonal codes are interlaced and thus a sequence of MxN elements is generated as the MRPOC Ci.

A user is assigned an MRPOC Ci for use in spreading data. The 0s and 1s of a data bit stream of the ith channel are changed to +1s and -1s respectively by the signal mapper 411. A signal spreading device 400 spreads the signal of +1s and -1s with the MRPOC Ci, performs a PN masking on the spread signal to discriminate between users or base stations, and outputs the PN-masked signal as a complex signal. The baseband filter 419 baseband-pass filters the complex signal

and the frequency shifter 421 shifts the signal received from the baseband filter 419 to an RF signal.

The signal spreading device 400 is composed of the MRPOC generator 413, the PN code generator 415, and MRPOC spreading and PN masking portion 417.

Figures 5A, 5B and 5C are examples of the MRPOC spreading and PN masking portion 417 shown in FIG 4, which are basically similar in structure to the general Walsh code spreading and PN masking portions using orthogonal code spreading device, except that the MRPOC spreading and PN masking portion 417 is substituted for the orthogonal code spreading, and PN masking portion and a PN sequence for PN masking is repeated M times, that is, the period of a PN code is M times longer to obtain the same spreading and masking effects. Here, M indicates that an interference signal can be reduced with respect to a path delay time of (M-1) chips, as compared to the orthogonal spreading using Walsh codes.

Referring to figure 5A, an MRPOC spreader 511 orthogonally spreads a signal of +1s and -1s received from the signal mapper 411 using a MRPOC Ci and separates the spread signal into a real part and an imaginary part. A repeater 513 repeats the PN codes, PNi and PNq received from the PN code generator 415, M times. A multiplier 515 multiplies the real part received from the MRPOC spreader 511 with the M times repeated PN codes, Pni, and generates a spread output Xi. A multiplier 517 multiplies the imaginary part received from the MRPOC spreader 511 with the M times repeated PN code, PNq, and generates a spread output Xq.

Figure 5B illustrates an MRPOC spreading and PN masking portion 417 arranged to increase the number of the available MRPOCs. A serial-to-parallel converter 521 separately outputs odd-numbered and even-numbered signals of +1s and -1s. Then, first and second spreaders multipliers 523 and 525 multiply the odd-numbered signal and the even-numbered signal by the MRPOC Ci, respectively. For PN masking, a multiplier 529 multiplies the output of the first spreader 523 by the M

times repeated PN code, Pni, and outputs the spread signal Xi. A multiplier 531 multiplies the output of the second spreader 525 by the M times repeated PN code, PNq, and outputs the spread signal Xq.

Since the transmission rate of a +1 or -1 signal in the directions of real and imaginary parts in half of that for the input in this method, the length of the MRPOC should be doubled. Thus, the number of available MRPOCs is increased by a factor of two.

Figure 5C is a block diagram of the MRPOC spreading and PN masking portion 417 arranged so that the number of available MRPOCs is doubled and PN masking is performed through complex spreading to make the signal strengths of a real part and an imaginary part equal. Referring to figure 5C, a serial-to-parallel converter 541 separately outputs real and imaginary parts of odd-numbered and even-numbered signals of +1s or -1s. Then, first and second spreaders 543 and 545 multiply the odd-numbered signal and the even-numbered signal by the MRPOC Ci, respectively, and output di and dq. A complex multiplier 549 multiplies di and dq by PNi and PNq, respectively and outputs PN-masked signals, Xi and Xq. Here, the complex multiplier 549 operates following equation (1).

In cases where a spread spectrum signal is generated by use of the MRPOC Ci generated accordingly to the embodiment of figure 5C, a correlation value between the MRPOC Ci and another MRPOC is 0, thereby enabling signal recovery without any interference.

In designing a transmitter employing the above spread spectrum method, the orthogonality loss involved in using Walsh codes due to multipath propagation can be suppressed if a delay time is within a predetermined range despite the existence of the multipath propagation characteristic. This is possible by ensuring orthogonality between delayed signal components arising from the multipath signals and a normal signal component. For this purpose, a signal is generally

spread with a combination of alternately arranged Walsh codes.

Figure 6 is a timing diagram of a combination of two alternately arranged, Walsh codes, which is mutually orthogonal to such a combination which is delayed by one chip-duration. In figure 6, the normal signal is obtained by combining two Walsh codes W1 and W2. That is, the Walsh codes are arranged in the order of the first element of the Walsh code W1, the first element of the Walsh code W2, the second element of the Walsh code W1, the second element of the Walsh code W2,...., the Nth element of the Walsh code W1, and the Nth element of the Walsh code W2. The newly combined code can be expressed as

$$W_{\text{no delay}} = \{W11\ W21\ W12\ W22\ W13\ W23,\ \ldots,\ W1N\ W2N\}$$

x and y of Wxy denote an orthogonal code number and an element number of the orthogonal code, respectively. Therefore, W11 is the first element of an orthogonal code W1, and W2N is an Nth element of an orthogonal code W2. Here, an element is a chip. Form example, for the number of elements in an orthogonal code=8, pairs of orthogonal codes for forming an MRPOC in the table of the MRPOC generator 413 may be listed as in (table 2).

(Table 2)

code index	Wx	Wy Wx1-Wx8
1	W1 W20	++++++++ +-+-+-+-
2	W2 W35	++--++-- +--++--+
3	W3 W63	++++---- +-+--+-+
4	W4 W11	++----++ +--+-++-

Therefore, with a code index of 1 an MRPOC is generated as "+++-+++-+++-+++-", and with a code index of 2, an MRPOC is generated as "+++----++++----+". In the MRPOC generating method as described above, M orthogonal codes are selected from N orthogonal codes, and their combinations are listed in the table. Then, an orthogonal code combination is selected according to a code index and the elements of the orthogonal codes in the combination are interlaced. Thus, MRPOCs Ci are generated. For interlacing, the selected M orthogonal codes are arranged in an MxN matrix and the elements of the orthogonal codes are read from the matrix by columns, thereby generating an MRPOC as a sequence of MxN elements.

A receiver separates the elements of the Walsh code W1 and those of the Walsh code W2 from the above code and decodes

them, independently. In this case, the normal signal maintains orthogonality since the correlation values between its Walsh code W1 and a reference Walsh code W1 and between its Walsh code W2 and a reference Walsh code W2 are N. For the one-chip delayed signal, a correlation value is calculated between the reference code W1 and W2 component of the input signal and between the reference code W2 component and a W1 component of the input signal. Since the codes W1 and W2 are different, the correlation value is 0. Therefore, combining Walsh codes in this manner may result in a code which is orthogonal to a signal delayed by one chip. By sequentially combining M different Walsh codes in such a manner as shown in figure 6, a correlation value with respect to a signal delayed by a maximum of (M-1) chips in maximum is always 0, and there exists a correlation value other than 0 with respect to only a normal signal. Thus, a code can be obtained which is orthogonal to a signal delayed by (M-1) chips.

However, a CDMA signal uses a PN code for discrimination between users and base stations and spectrum spreading. The PN code is multiplied by data to be spread. Hence, it is impossible to ensure full orthogonality for the CDMA signal because the orthogonality of a Walsh code with respect to a one chip-delayed signal is lost due to multiplication of the PN code by the Walsh code. To prevent this, a common PN code should be applied to a pair of values resulting from two Walsh codes. In this case, one of the two correlation calculations with respect to the Walsh codes W1 and W2 shows orthogonality and the other results in a value other than 0 (the correlation value obtained from a general Walsh function), in the example of figure 6. Therefore, a correlation value with respect to a one chip delayed signal is not 0 but a half of the correlation value that would be derived from the general Walsh code.

In the case of (M-1) chip delay, a correlation value of 1/M is calculated for one chip-delay and 2/M for a two chip-delay. Figures 7A and 7B are graphs of correlation

characteristics of a Walsh code combination, which are improved despite even an (M-1) chip-multipath propagation delay. It is noted from the drawings that the interference when using the combined Walsh code of the present invention is reduced as compared to that caused by a one chip-delayed signal and results in a loss of orthogonality of about $(10*\log_{10}M)$dB. For example, with M=2, the interference drops by about 3dB, and with M=4, by about 6dB.

Figure 8 is a block diagram of an MRPOC spreader using the above pseudo-orthogonal code. The MRPOC spreader of figure 8 may be one of those shown in figures 5A, 5B and 5C.

Referring to figure 8, an input to the MRPOC spreader is a signal sequence of +1s and -1s with a transmission rate of K. The input signal sequence is divided into M branches by a serial-to-parallel converter 811, with each divided signal sequence of +1s and -1s having a transmission rate of K/M. That is, the serial-to-parallel converter 811 acts to assign sequentially signals of +1s or -1s to 1 to M branches. Hence, each branch transmits a signal and a transmission rate of $\frac{1}{M}$.

Assume that an MRPOC is composed of M different Walsh codes and has a length of N. In this case, each signal value at a branch is spread with an N Walsh code sequence.

If a signal at each branch is ai(i=1,2, ...,and M)a Walsh code for the branch is Wi(i=1,2,...,and M), and an element of a Walsh code is Wij(i=1,2,...,and M, and j=1,2,...,and N); a spread signal from each branch can be given in a matrix as shown in the following

$$a_1W_1 = [a_1W_{11}, a_1W_{12}, a_1W_{13}, \ldots, a_1W_{1N}] \ldots\ldots (3)$$

$$\begin{vmatrix} a_1W_{11} & a_1W_{12} & a_1W_{13} & \cdots & a_1W_{1N} \\ a_2W_{21} & a_2W_{22} & a_2W_{23} & \cdots & a_2W_{2N} \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ a_MW_{M1} & a_MW_{M2} & a_MW_{M3} & \cdots & a_MW_{MN} \end{vmatrix} \ldots\ldots (4)$$

The parallel-to-serial converter 817 reads the above matrix by columns and outputs the read sequence at a data rate of KxN, given as

$$a_1W_{11}\ a_2W_{21}, \ldots, a_MW_{M1}, a_1W_{12}, aW_{33}, \ldots, a_MW_{MN}$$

That is, the MRPOC spreader changes M data signals of +1s or -1s to MxN signal sequences resistant against a multipath propagation signal delayed by a maximum of (M-1) chips.

The above MRPOCs can be simply generated by use of a general orthogonal code of which, Walsh codes are an example. Other orthogonal codes may be substituted for the Walsh codes to obtain the same effect.

The spread spectrum signal generating method using MRPOCs and the MRPOC generating method have been described in detail. A transmitter using an MRPOC can transmit a signal without interference on a single path propagation channel as with an orthogonal code, and remarkably reduce interference as long as the multipath propagation channel delay does not exceed a delay time of (M-1) chips relative to the orthogonal code.

As for a reverse link in IS-95, only a PN code is applied to a reverse traffic channel to discriminate between users due to the difficulty in ensuring that signals from terminals arrive at a base station at the same time. However, use of the MRPOCs can increase reception performance remarkably relative to the use of a PN code only if transmission signals from the terminals can reach the base station within a time period of (M-1) chips.

In the absence of techniques for concurrent arrival of signals from terminals at a base station, the MRPOCs are useful to some extent. A signal is transmitted from a terminal to the base station on a multipath propagation channel, and the base station performs a despreading using the MRPOC of the corresponding terminal to receive the signal from the terminal. In this process, the base station obtains a signal having a signal component and an interference component. The signal component derives from the signal of the corresponding terminal and the interference component derives from a signal transmitted from another terminal and a delayed signal component from the corresponding terminal. Since there is no effort for concurrent arrival of the transmission signals from the terminals to the base station, the interference component originating from the terminals except for the corresponding terminal appears from the unsynchronized random PN codes. The interference component from the delay signal component of the corresponding terminal is smaller than that from the unsynchorinized random PN code if the delay time is within (M-1) chips.

In this context, application of MRPOC to a reverse link can reduce an interference signal generated from a different terminal or a delayed signal from a corresponding terminal, regardless of time alignment for terminals. Needless to say, the inclusion of time alignment reduces the effect of interference signals to an even greater extent when used in conjunction with an MRPOC.

Figure 9 is a block diagram of a transmitter on a reverse link, to which an MRPOC spreader is applied to increase performance.

Referring to figure 9, a first signal mapper 911 changes 0s and 1s of an input pilot/control channel data bit stream to +1s and -1s respectively. A second signal mapper 913 also changes 0s and 1s of an input traffic channel data bit stream to +1s and -1s respectively. An MRPOC generator 915 generates an MRPOC, Ci, assigned by the code index of a

corresponding channel. A PN code generator 917 generates PN codes, PNi and PNq for a real part and for an imaginary part. A reverse link MRPOC spreading and PN masking portion 919 spreads the signals received from the first and second signal mappers 911 and 913 with the MRPOC, Ci, and multiplies the spread signal by the PN codes, PNi and PNq, respectively, and generates PN-masked signals Xi and Xq. A baseband filter 921 baseband-pass filters the signals Xi and Xq and a frequency shifter 923 shifts the frequency of the signal received from the baseband filter 921 to an RF frequency.

In figure 9 it is assumed that a pilot/control channel being a reference signal and a traffic channel are occupied by a user terminal.

Referring to figure 9, the user terminal transmits a data bit of 1 or 0 on the traffic channel and a data bit of 1 or 0 as a reference signal on the pilot/control channel, for synchronous demodulation of the traffic channel. The data 1s or 0s are converted to +1s and -1s by the first and second signal mappers 911 and 913. Then, the reverse link MRPOC spreading and PN masking portion 919 generates a spread complex baseband signal with a real component of Xi and an imaginary component of Xq. The baseband filter 921 modulates the signal received from the MRPOC spreading and PN masking portion 919 in an OQPSK (Offset Quadrature Phase Shift Keying) method and filters the modulated signal. The frequency shifter 923 converts the output of the baseband filter 921 to an RF spread signal.

The reverse link MRPOC spreading and PN masking portion 919 can be modified in various ways. Figure 10 is a block diagram of the reverse link MRPOC spreading and PN masking portion 919 in which MRPOCs are applied to the pilot/control channel and the traffic channel and PN masking is performed by complex spreading. Figure 11 is a block diagram of the reverse MRPOC spreading and PN masking portion 919 in which MRPOCs are applied to the pilot/control channel and the traffic channel and no complex spreading is performed for PN

masking. Figure 12 is a block diagram of a reverse link MRPOC spreading and PN masking portion 919 in which an MRPOC is applied only to the traffic channel and no complex spreading is performed for PN masking. Figure 13 is a block diagram of a reverse link MRPOC spreading and PN masking portion 919 in which odd-numbered and even-numbered bits are separated from the traffic channel, an MRPOC is applied to the odd-numbered and even-numbered bits, and no complex spreading is performed for PN masking. Figure 14 is a block diagram of a reverse MRPOC spreading and PN masking portion 919 in which odd-numbered and even-numbered bits are separated from the traffic channel, an MRPOC is applied to the odd-numbered and even numbered bits, and complex spreading is performed for PN masking.

Referring to figure 10, a first spreader 1011 multiplies an input pilot/control channel signal by an MRPOC, Ci, and outputs a spread signal di. A second spreader 1013 multiplies an input traffic channel signal by an MRPOC, Cj, and outputs a spread signal dq. A repeater 1017 repeats the PN codes, PNi and PNq, received from the PN code generator 917 at predetermined number of times. A complex multiplier 1019 complex multiplies the spread signals di and dq by the repeated PN codes, PNi and PNq, received from the repeater 1017 and generates PN masked signals Xi and Xq. The complex multiplier 1019 operates as in equation (1) for complex PN masking.

In figure 10, the MRPOCs, Ci and Cj, should be different from each other, which implies that the respective subcodes of the MRPOCs, Ci and Cj should be different. In this reverse link MRPOC spreading and PN masking portion 919, the pilot/channel and the traffic channel can concurrently arrive at a base station, and thus mutual interference can be removed. However, the number of available MRPOCs is reduced by half.

Referring to figure 11, a first spreader 1111 multiplies an input pilot/control channel signal by an MRPOC, Ci and outputs the spread signal di. A second spreader 1113

multiplies an input traffic channel signal by an MRPOC, Cj, and outputs the spread signal dq. An adder 1115 adds the spread signal di received from the first spreader 1111 and the spread signal dq received from the second spreader 1113, and generates a signal di+dq. An adder 1117 adds the signal dq and di and generates a signal dq+di. A repeater 1121 repeats the PN codes, PNi and PNq, received from the PN code generator 917 at predetermined number of times. A multiplier 1123 multiplies the spread signal di+dq received from the adder 1115 by the repeated PN code, Pni, received from the repeater 1121 and generates the PN masked signal Xi. A multiplier 1125 multiplies the spread signal dq+di received from the adder 1117 by the repeated PN code, PNq received from the repeater 1121 and generates the PN masked signal Xq.

In figure 11, the MRPOCs, Ci and Cj should be different from each other. In this reverse link MRPOC spreading and PN masking portion 919, the pilot/control channel and the traffic channel can concurrently arrive at a base station, and thus mutual interference can be removed. However, the number of available MRPOCs is reduced by half.

Referring to figure 12, an MRPOC spreader 1211 multiplies an input traffic channel signal by an MRPOC, Ci, and generates a spread signal. A repeater 1215 repeats the PN codes, PNi and PNq, received from the PN code generator 917 at predetermined number of times. A multiplier 1217 multiplies an input pilot/control channel signal by a PN code, Pni and a multiplier 1219 multiplies the input pilot/control channel signal by a PN code, PNq. A multiplier 1221 multiplies the spread signal received from the MRPOC spreader 1211 by the repeated PN code, Pni, received from the repeater 1215, and a multiplier 1223 multiplies the spread signal received from the MRPOC spreader 1211 by the repeated PN code, PNq, received from the repeater 1215. An adder 1225 adds the outputs of the multipliers 1217 and 1221 and generates the PN masked signal Xi, and an adder 1227 adds the outputs of the multipliers 1219 and 1223 and generates the PN masked signal Xq.

In figure 12, because an MRPOC is not applied to the pilot/control channel, there is no orthogonality between the pilot/control channel and the traffic channel. Thus, the channels are likely to suffer interference due to the PN codes. In addition, the PN codes for spreading the pilot/traffic channel should be different from those for spreading the traffic channel, and users should be assigned different PN codes.

Referring to figure 13, a serial-to-parallel converter 1315 separately outputs even-numbered and odd-numbered bits of an input traffic channel signal. A first spreader 1317 multiplies the even-numbered bits received from the serial-to-parallel converter 1315 by an MRPOC, Ci and a second spreader 1319 multiplies the odd-numbered bits received from the serial-to-parallel converter 1315 by the MRPOC, Ci. A repeater 1323 repeats the PN codes, PNi and PNq received from the PN code generator 917 at predetermined number of times. A multiplier 1311 multiplies an input pilot/control channel signal by a PN code, PNi, and a multiplier 1313 multiplies the input pilot/control channel signal by the PN code, PNq. A multiplier 1325 multiplies the spread signal received from the first spreader 1317 by a PN code, PNi, received from the repeater 1323, and a multiplier 1327 multiplies the spread signal received from the second spreader 1319 by a PN code, PNq, received from the repeater 1323. An adder 1329 adds the outputs of the multipliers 1311 and 1325 and outputs the PN masked signal Xi. An adder 1311 adds the outputs of the multipliers 1313 and 1327 and outputs the PN masked signal Xq.

In figure 13, the traffic channel data is divided into two branches by the serial-to-parallel converter 1315 and an MRPOC double the length of the original MRPOC is applied to each divided signal to increase the number of available MRPOCs. The traffic channel data is separated into even numbered data and odd numbered data by the serial-to-parallel converter 1315. Since the data transmission rate of the data in each branch is a half that at the input to the serial-to-

parallel converter 1315, the length of the MRPOC should be doubled, and thus the number of the MRPOCs is generally doubled. Therefore, the number of the available MRPOCs is twice that for the structures of figures 11 and 12. An identical MRPOC is applied to the even numbered and odd numbered data of the traffic channel. The respective spread signals forms a real part and an imaginary part after PN masking, and are added to spread real and imaginary parts of the pilot/control channel, respectively.

Referring to figure 14, a serial-to-parallel converter 1415 separately outputs even numbered and odd numbered bits of an input traffic channel signal. A first spreader 1417 multiplies the even numbered bits received from the serial-to-parallel converter 1415 by an MRPOC, Ci, to produce spread signal di. A second spreader 1419 multiplies the odd numbered bits received from the serial-to-parallel converter 1415 by the MRPOC, Ci to produce spread signal dq. A repeater 1423 repeats the PN codes, PNi and PNq received from the PN code generator 917 at predetermined number of times. A multiplier 1411 multiplies an input pilot/control channel signal by a PN code, PNi, and a multiplier 1413 multiplies the input pilot/control channel signal by the PN code, PNq. A complex multiplier 1425 complex multiplies the spread signals di and dq received from the first and second spreaders 1417 and 1419 by the PN codes, PNi and PNq received from the repeater 1423 as per in equation (1). An adder 1427 adds the output of the multiplier 1411 and the spread signal Xi received from the complex multiplier 1425 and outputs the PN masked signal Xi. An adder 1429 adds the output of the multiplier 1413 and the spread signal Xq received from the complex multiplier 1425 and outputs the PN masked signal Xq.

The method of figure 14 is similar to that of figure 13 except that complex spreading is performed for PN masking of the traffic channel to make the strengths of the spread real and imaginary signals equal.

The structures of the reverse link MRPOC spreading and PN masking portion 919 shown in figures 10 to 14 should be designed to be applicable to a cellular mobile communications system. As base stations cannot be differentiated with a single MRPOC set, the number of MRPOC sets preferably should be equal to the number of base stations or a reuse factor. However, it may not be practical to make so many sets of codes and thus there is a need for a method of making another MRPOC set given an existing MRPOC set. For this purpose, the PN masking is used.

When every base station uses a different PN code in the cellular mobile communications system, an MRPOC set can be commonly applied to base stations in such a way that the base stations in effect use different MRPOCs. In this case, the MRPOC sets mutually serve as PN codes and thus the intensity of an interference signal is proportional to the length of the PN codes. Yet, mutual orthogonality is maintained among elements of an MRPOC set. As a result, PN masking for differentiating MRPOC sets allows the development if as many MRPOC sets as there are base stations.

There will hereinbelow be given a description of a forward MRPOC spreading and PN masking portion.

Spectrum spreading and discrimination among users or channels are implemented using an orthogonal codes on a forward link in a CDMA mobile communications system of IS-95 or any other standard. Since all channels can be synchronised with a base station on a forward link, a transmission signal from the base station can be demodulated by a specific terminal without interference from a signal transmitted from the base station to a different terminal, only if the transmissions is conducted via a single path channel on the forward link. However, if signals are transmitted from the base station on multipath channels, an interference signal is generated by a signal from the base station to a different terminal.

Accordingly, application of MRPOCs to the forward link contributes to reduction of an interference signal caused by

multipath propagation, thereby reducing the operational signal strength point of the forward link. As a result, system capacity is increased.

Then, the number of available MRPOCs should be increased. This can be achieved by the same method as that for the reverse link. That is, a serial-to-parallel converter separately outputs odd-numbered data and even numbered data of traffic channel data, each at half the data rate of the input traffic channel data, and each separated signal is spread twice, so that the number of available MRPOCs is doubled and an MRPOC induced system capacity increase can be realised.

According to the present invention as described above, the loss of orthogonality caused by a multipath propagation signal component in a spread spectrum method using a Walsh code is prevented by spreading a signal with an MRPOC in a transmitter of a mobile communications system.

While the present invention has been described in detail with reference to the specific embodiments, they are mere exemplary applications. Thus, it is to be clearly understood that many variations can be made by anyone skilled in the art within the scope and spirit of the present invention.

CLAIMS

1. A pseudo-orthogonal code generating method for spreading input channel data in a CDMA communication system, the method comprising the steps of
selecting M orthogonal codes from N orthogonal codes for forming a pseudo-orthogonal code; and
interlacing the elements of the selected M orthogonal codes to generate the pseudo orthogonal code as a sequence of MxN elements.

2. A method as claimed in claim 1, wherein the step of interlacing comprises the steps of
arranging the selected orthogonal codes in a matrix of M rows by N columns; and
outputting the elements of the orthogonal codes from the matrix by columns.

3. A method as claimed in either of claims 1 or 2, wherein the orthogonal codes are Walsh codes.

4. A method as claimed in any preceding claim, wherein the input channel data is a traffic data.

5. A method as claimed in any preceding claim, wherein M is 2.

6. A method as claimed in any preceding claim, further comprising the step of
multiplexing, using a multiplexer, input channel data to produce M-branch parallel data;
spreading, using a plurality of spreaders, the multiplexed M-branch parallel data; and
demultiplexing, using a demultiplexer, the parallel spread data to produce serial data.

7. A spread spectrum method using a pseudo-orthogonal code

in a CDMA communication system, the method comprising the steps of

converting, using a signal converter, at least one input channel data bit stream into a converted signal;

generating a pseudo-orthogonal code which is a combination of M different orthogonal codes using a pseudo-orthogonal code generating method as claimed in any of claims 1 to 6,

generating, using a PN code generator, a PN code comprising real and imaginary component parts;

pseudo-orthogonal code spreading and PN masking, using a pseudo-orthogonal code spreading and masking portion, by dividing the converted signal into M signal sequences, multiplying each signal sequence by the pseudo-orthogonal code, generating MxN sequences; and multiplying each spread signal sequence by a PN code for PN masking; and

baseband filtering, using a baseband filter, the output of the pseudo-orthogonal code spreading and masking portion to produce a filtered signal; and shifting, using a frequency shifter, the frequency of the filtered signal.

8. A method as claimed in claim 7, wherein the step of pseudo-orthogonal code spreading and PN masking comprises the steps of

converting, using a pseudo-orthogonal code spreader, the converted signal into M parallel signal sequences, multiplying each signal sequences by the pseudo-orthogonal code, generating MxN spread signal sequences, spreading the M signal sequences, and converting the M spread signal sequences to a serial sequence;

repeating, using a repeater, M times the real component of the PN code and the imaginary component of the PN code received from the PN code generator;

multiplying, using a first multiplier, the output of the pseudo-orthogonal code spreader by the real component of the PN code received from the repeater for PN masking the real component of a real part signal; and

multiplying, using a second multiplier, the output of the pseudo-orthogonal code spreader by the imaginary component of

the PN code received from the repeater for PN masking of an imaginary part signal.

9. A method as claimed in either of claims 7 or 8, further comprising the step of
separating, using a serial to parallel converter, even-numbered and odd-numbered bits from the converted signal;
converting, using a first pseudo-orthogonal code spreader, the even-numbered bit signal to M parallel signal sequences, multiplying each signal sequence by the pseudo-orthogonal code, generating MxN spread signal sequences, spreading the M signal sequences and converting the M spread signal sequences to a serial sequence; and
converting, using a second pseudo-orthogonal code spreader, the odd-numbered bit signal to M parallel signal sequences, multiplying each signal sequence by the pseudo-orthogonal code, generating MxN spread signal sequences, spreading the M signal sequences and converting the M spread signal sequences to a serial sequence.

10. A method as claimed in any of claim 7 to 9, further comprising the steps of
dividing input channel data, using a serial-to-parallel converter, of a transmission rate of K into M signal sequences each having a transmission rate of K/M; and wherein the step of multiplying comprises
multiplying, using a plurality of multipliers, the M signal sequences by M different orthogonal, preferably Walsh, codes each having a length of N and generating spread signals in a matrix of a_iW_{ij}, where a_i is a divided signal sequence and W_{ij} is an element of each orthogonal, preferably Walsh, code;
converting, using a serial-to-parallel converter, the spread spectrum signals in the form a matrix to serial data of a transmission rate of K;
multiplying, using a first multiplier, the serial data by the real PN code component for PN masking; and
multiplying, using a second multiplier, the serial data by the imaginary PN code component for PN masking.

11. A method as claimed in any of claim 7 to 9, further comprising the steps of
dividing input channel data, using a serial-to-parallel converter, of a transmission rate of K into M signal sequences each having a transmission rate of K/M; and wherein the step of multiplying comprises
multiplying, using a plurality of multipliers, the M signal sequences by M different orthogonal, preferably Walsh, codes each having a length of N and generating spread signals in a matrix of a_iW_{ij}, where a_i is a divided signal sequence and W_{ij} is an element of each orthogonal, preferably Walsh, code;
converting, using a serial-to-parallel converter, the spread spectrum signals in the form a matrix to serial data of a transmission rate of K;
complex-multiplying, using a complex multiplier, the serial data by the real and imaginary PN code components.

12. A method as claimed in any of claim 7 to 11, wherein the step of converting, using a signal converter, an input channel data bit stream into a converted signal comprises the steps of
converting, using signal converter, 0s and 1s of the at least one input channel data bit stream into corresponding +1s and -1s respectively.

13. A pseudo-orthogonal code generating device for spreading channel data in a CDMA communication system, the device comprising
means for selecting M orthogonal codes from N orthogonal codes for forming a pseudo-orthogonal code; and
means for interlacing the elements of the selected M orthogonal codes to generate the pseudo orthogonal code as a sequence of MxN elements.

14. A device as claimed in claim 13, wherein the means for interlacing comprises
means for arranging the selected orthogonal codes in a matrix

of M rows by N columns; and
means for outputting the elements of the orthogonal codes from the matrix by columns.

15. A device as claimed in either of claims 13 or 14, wherein the orthogonal codes are Walsh codes.

16. A device as claimed in any of claims 13 to 15, wherein the channel data is a traffic data channel.

17. A device as claimed in any of claims 13 to 16, wherein M is 2.

18. A device as claimed in any of claims 13 to 17, further comprising
means for multiplexing, using a multiplexer, input channel data to produce M-branch parallel data;
means for spreading, using a plurality of spreaders, the multiplexed M-branch parallel data; and
means for demultiplexing, using a demultiplexer, the parallel spread data to produce serial data.

19. A spread spectrum device using a pseudo-orthogonal code in a CDMA communication system, the device comprising
a signal converter for converting an input channel data bit stream into a converted signal;
a pseudo-orthogonal code generator for generating a pseudo-orthogonal code which is a combination of M different orthogonal codes using a pseudo-orthogonal code generating device as claimed in any of claims 13 to 18,
a PN code generator for generating a PN code comprising real and imaginary component parts;
a pseudo-orthogonal code spreading and masking portion for dividing the converted signal into M signal sequences, multiplying each signal sequence by the pseudo-orthogonal code, generating MxN sequences; and multiplying each spread signal sequence by a PN code for PN masking; and
a baseband filter for baseband filtering the output of the

pseudo-orthogonal code spreading and masking portion to produce a filtered signal; and a frequency shifter for shifting the frequency of the filtered signal.

20. A device as claimed in claim 19, wherein the pseudo-orthogonal code spreading and PN masking portion comprises
a pseudo-orthogonal code spreader for converting the converted signal into M parallel signal sequences, multiplying each signal sequences by the pseudo-orthogonal code, generating MxN spread signal sequences, spreading the N signal sequences, and converting the M spread signal sequences to a serial sequence;
a repeater for repeating M times the real component of the PN code and the imaginary component of the PN code received from the PN code generator;
a first multiplier for multiplying the output of the pseudo-orthogonal code spreader by the real component of the PN code received from the repeater for PN masking the real component of a real part signal; and
a second multiplier for multiplying the output of the pseudo-orthogonal code spreader by the imaginary component of the PN code received from the repeater for PN masking of an imaginary part signal.

21. A device as claimed in either of claims 19 or 20, further comprising
a serial-to-parallel converter for separating even-numbered and odd-numbered bits from the converted signal;
a first pseudo-orthogonal code spreader for converting the even-numbered bit signal to M parallel signal sequences, multiplying each signal sequence by the pseudo-orthogonal code, generating MxN spread signal sequences, spreading the M signal sequences and converting the M spread signal sequences to a serial sequence; and
a second pseudo-orthogonal code spreader for converting the odd-numbered bit signal to M parallel signal sequences, multiplying each signal sequence by the pseudo-orthogonal code, generating MxN spread signal sequences, spreading the N

signal sequences and converting the M spread signal sequences to a serial sequence.

22. A device as claimed in any of claim 19 to 21, further comprising

a serial to parallel converter for dividing input channel data of a transmission rate of K into M signal sequences each having a transmission rate of K/M; and wherein the means for multiplying comprises

a plurality of multipliers for multiplying the M signal sequences by M different orthogonal, preferably Walsh, codes each having a length of N and generating spread signals in a matrix of a_iW_{ij}, where a_i is a divided signal sequence and W_{ij} is an element of each orthogonal, preferably Walsh, code;

a serial-to-parallel converter for converting the spread spectrum signals in the form a matrix to serial data of a transmission rate of K;

a first multiplier for multiplying the serial data by the real PN code component for PN masking; and

a second multiplier for multiplying the serial data by the imaginary PN code component for PN masking.

23. A device as claimed in any of claim 19 to 21, further comprising

a serial to parallel converter for dividing input channel data of a transmission rate of K into M signal sequences each having a transmission rate of K/M; and wherein the means for multiplying comprises

a plurality of multipliers for multiplying the M signal sequences by M different orthogonal, preferably Walsh, codes each having a length of N and generating spread signals in a matrix of a_iW_{ij}, where a_i is a divided signal sequence and W_{ij} is an element of each orthogonal, preferably Walsh, code;

a serial to parallel converter for converting the spread spectrum signals in the form a matrix to serial data of a transmission rate of K;

a complex multiplier for complex-multiplying the serial data by the real and imaginary PN code components.

24. A device as claimed in any of claim 19 to 23, wherein the signal converter for converting an input channel data bit stream into a converted signal comprises
a signal converter for converting 0s and 1s of the at least one input channel data bit stream into corresponding +1s and -1s respectively.

ABSTRACT

Pseudo-orthogonal Code Generating Method and Device

The present invention relates to a pseudo-orthogonal code generating method and devices for use spreading channel data in a CDMA mobile communication system. There is provided a pseudo-orthogonal code generating method for spreading input channel data in a CDMA communication system, the method comprising the steps of selecting M orthogonal codes from N orthogonal codes for forming a pseudo-orthogonal code; and interlacing the elements of the selected M orthogonal codes to generate the pseudo orthogonal code as a sequence of MxN elements.

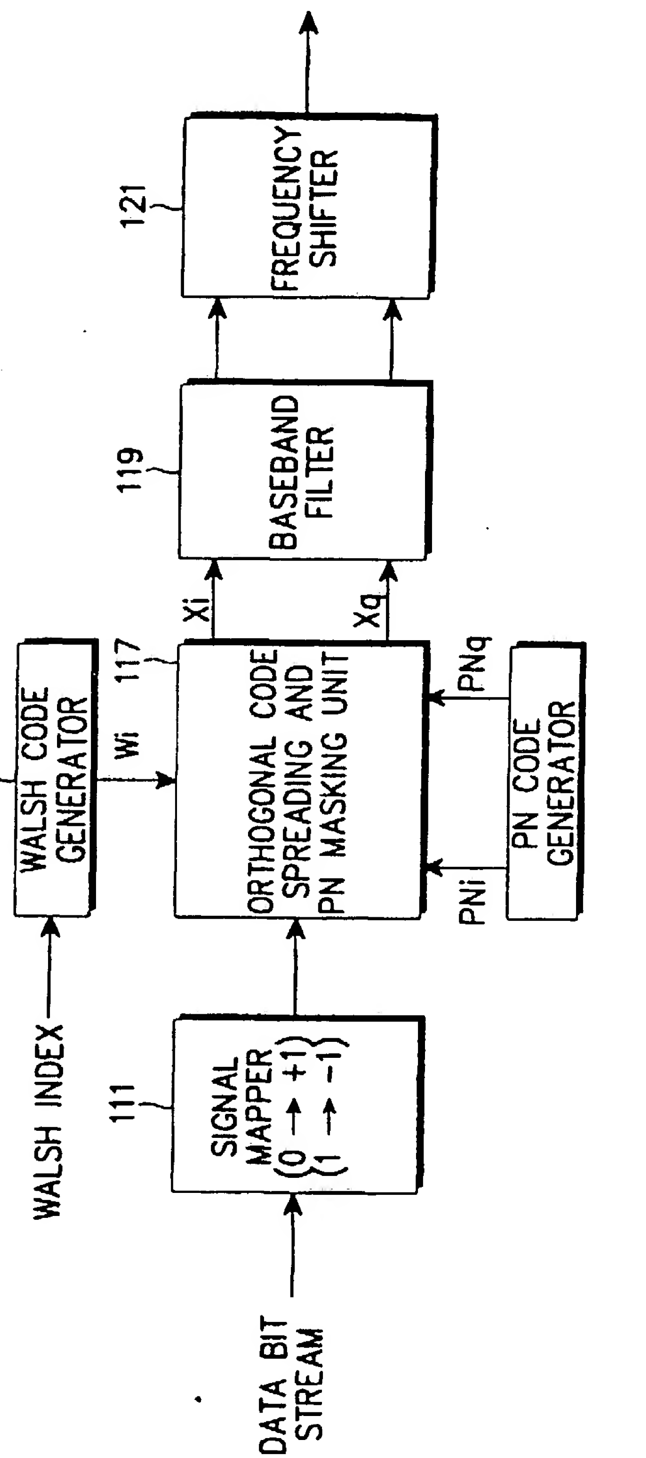

FREQUENCY SHIFTER
121
BASEBAND FILTER
119
Xi
Xq
WALSH CODE GENERATOR
113
Wi
ORTHOGONAL CODE SPREADING AND PN MASKING UNIT
117
PNq
PNi
PN CODE GENERATOR
WALSH INDEX
SIGNAL MAPPER (0 → +1) (1 → -1)
111
DATA BIT STREAM

FIG. 1

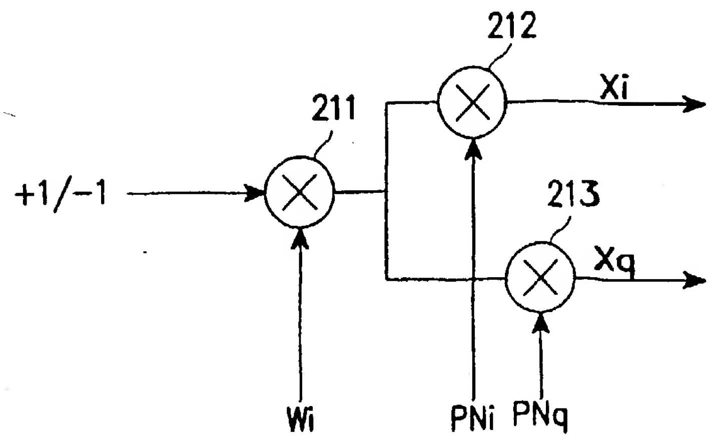

212
211
Xi
+1/-1
213
Xq
Wi
PNi PNq

FIG. 2A

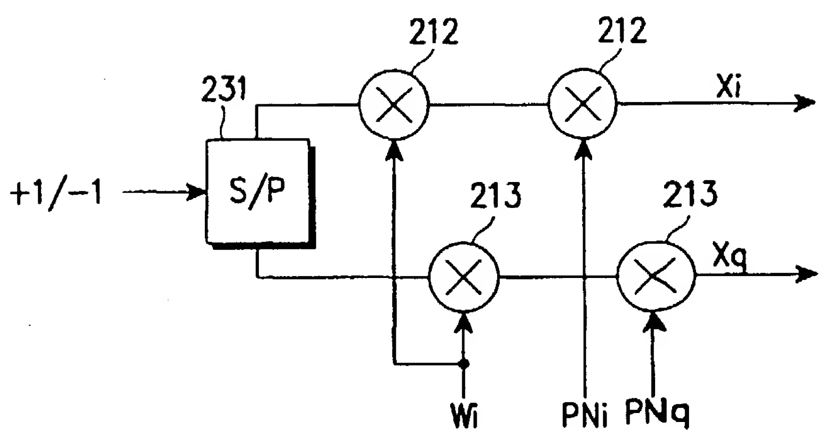

212
212
231
Xi
+1/-1
S/P
213
213
Xq
Wi
PNi PNq

FIG. 2B

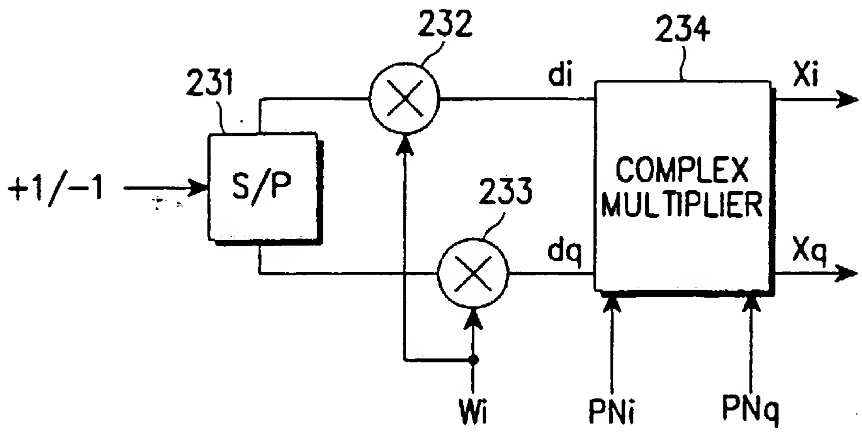


FIG. 2C

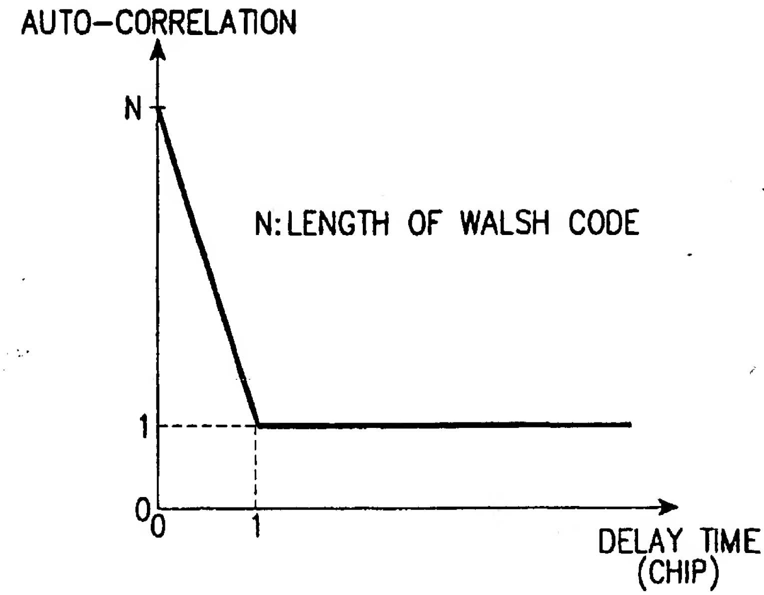

AUTO-CORRELATION
N
N:LENGTH OF WALSH CODE
1
0
0
1
DELAY TIME
(CHIP)

FIG. 3A

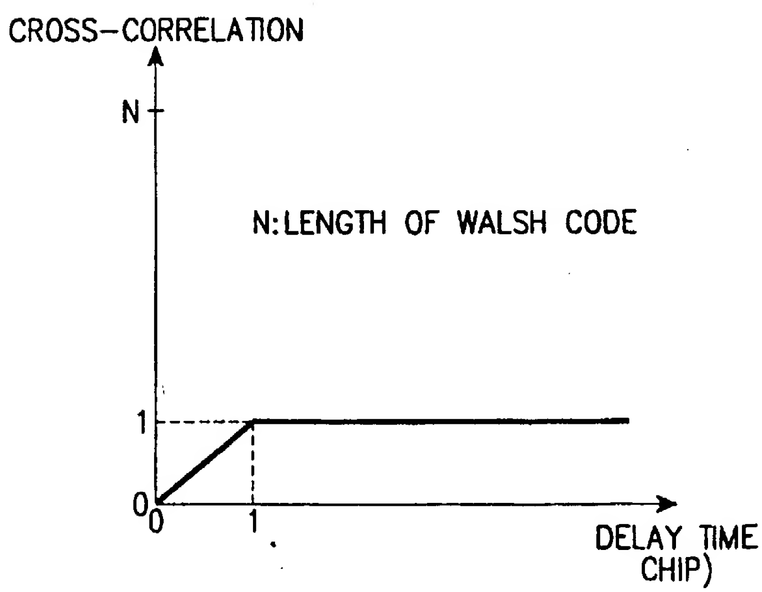
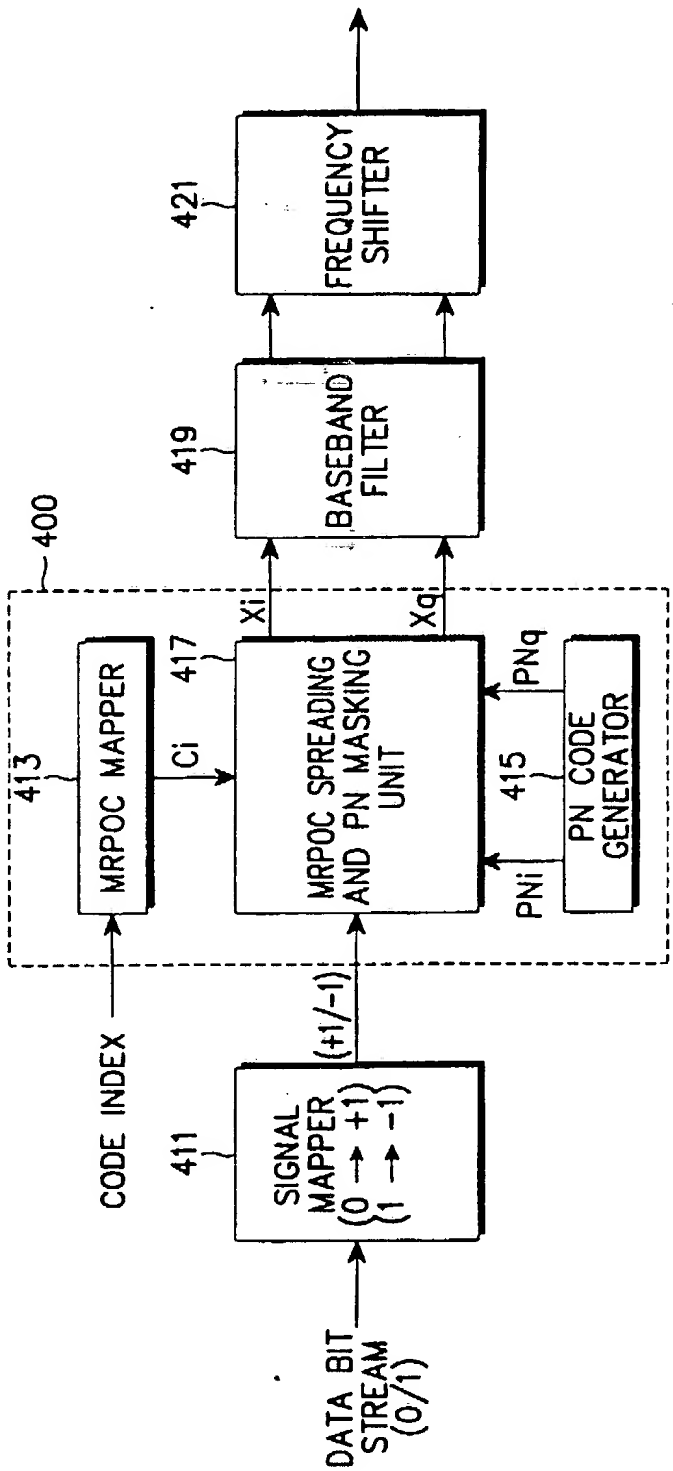

CROSS-CORRELATION
N
N:LENGTH OF WALSH CODE
1
0
0
1
DELAY TIME
CHIP)

FIG. 3B



400
FREQUENCY SHIFTER
421
BASEBAND FILTER
419
Xi
Xq
MRPOC MAPPER
413
Ci
MRPOC SPREADING AND PN MASKING UNIT
417
PNq
PNi
PN CODE GENERATOR
415
CODE INDEX
(+1/-1)
SIGNAL MAPPER
(0 → +1)
(1 → -1)
411
DATA BIT STREAM (0/1)

FIG. 4

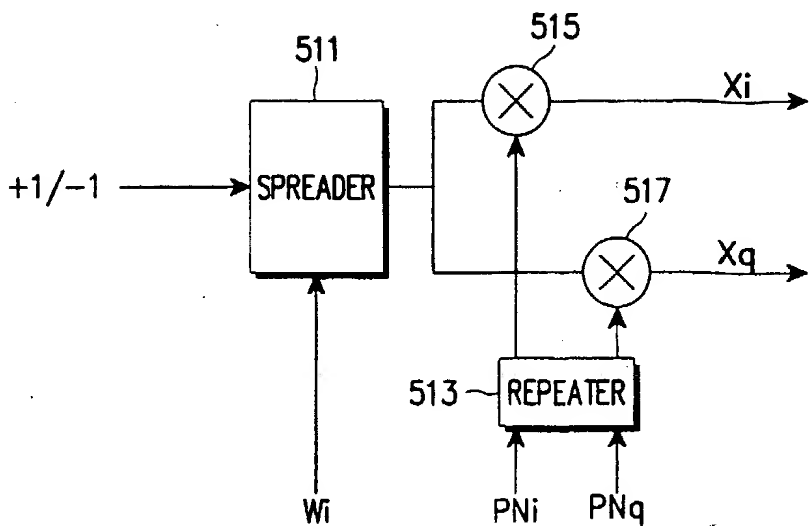

511
515
Xi
+1/-1
SPREADER
517
Xq
513
REPEATER
Wi
PNi
PNq

FIG. 5A

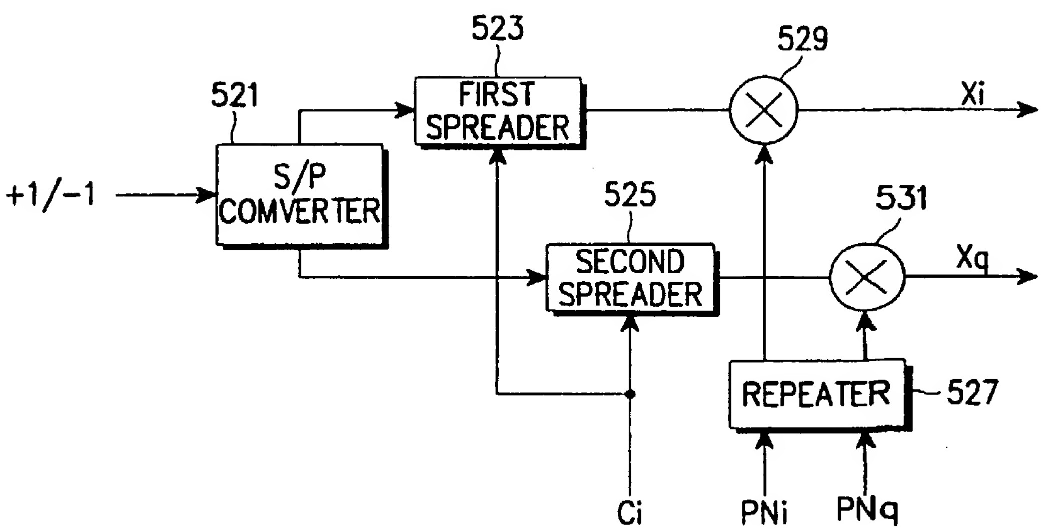

523
529
521
FIRST SPREADER
Xi
S/P COMVERTER
+1/-1
525
531
SECOND SPREADER
Xq
REPEATER
527
Ci
PNi
PNq

FIG. 5B

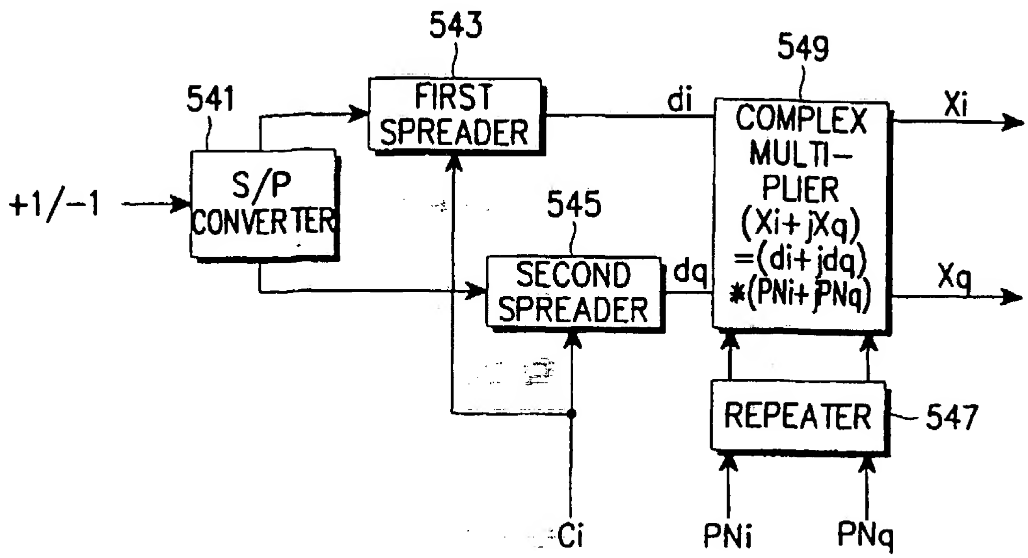

543
549
541
FIRST SPREADER
di
COMPLEX MULTI-PLIER (Xi+jXq) =(di+jdq) *(PNi+jPNq)
Xi
+1/-1
S/P CONVERTER
545
SECOND SPREADER
dq
Xq
REPEATER
547
Ci
PNi
PNq

FIG. 5C

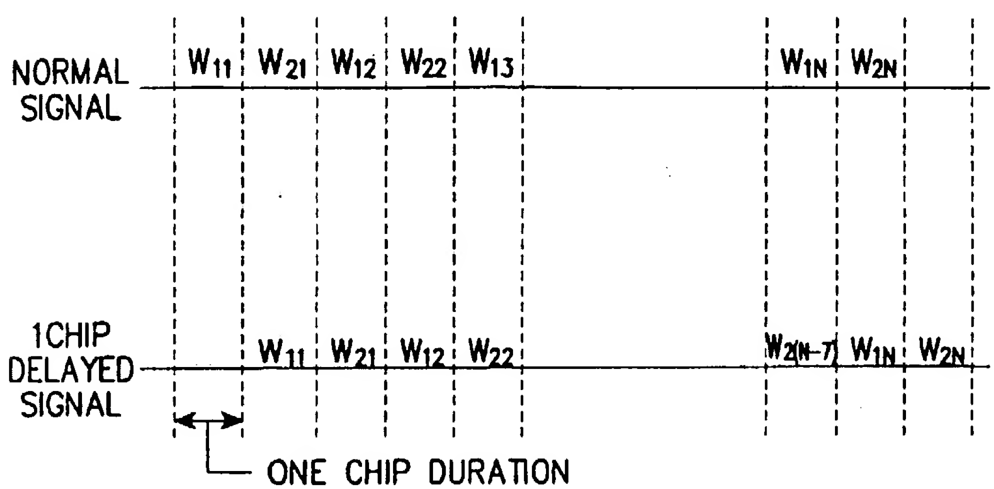

NORMAL SIGNAL
W11
W21
W12
W22
W13
W1N
W2N
1CHIP DELAYED SIGNAL
W11
W21
W12
W22
W2(N-1)
W1N
W2N
ONE CHIP DURATION

FIG. 6

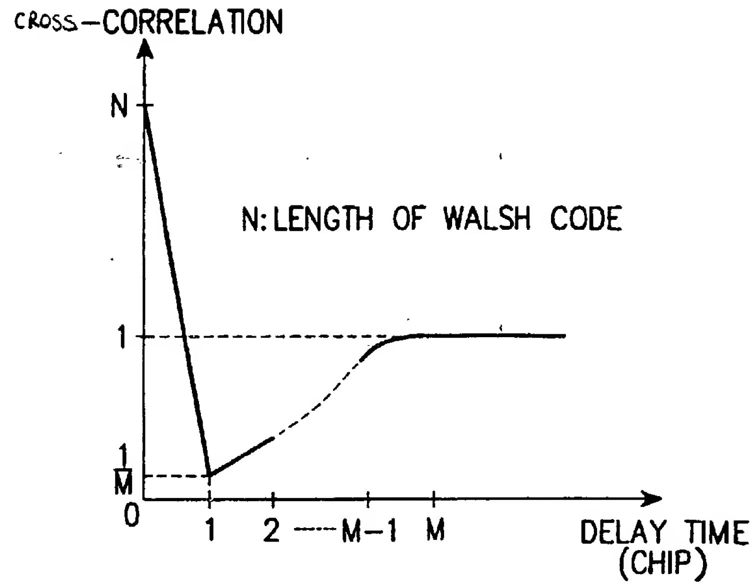

CROSS-CORRELATION
N
N: LENGTH OF WALSH CODE
1
1/M
0
1 2 ---- M-1 M
DELAY TIME (CHIP)

FIG. 7A

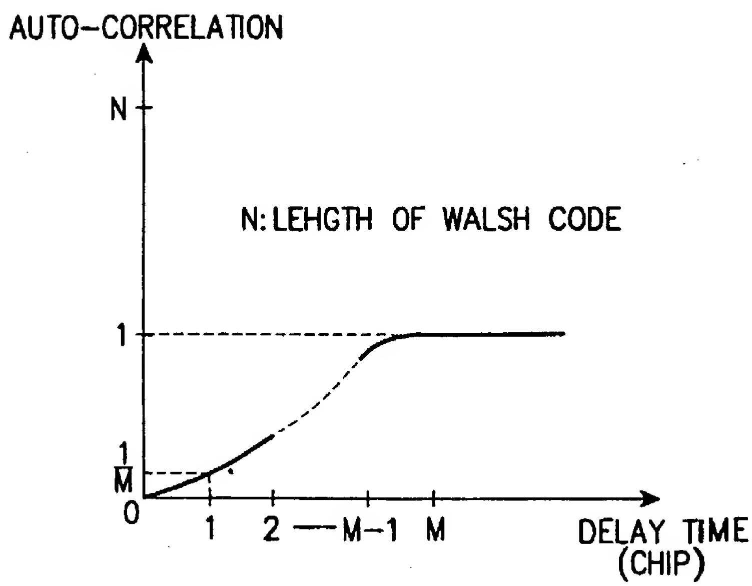
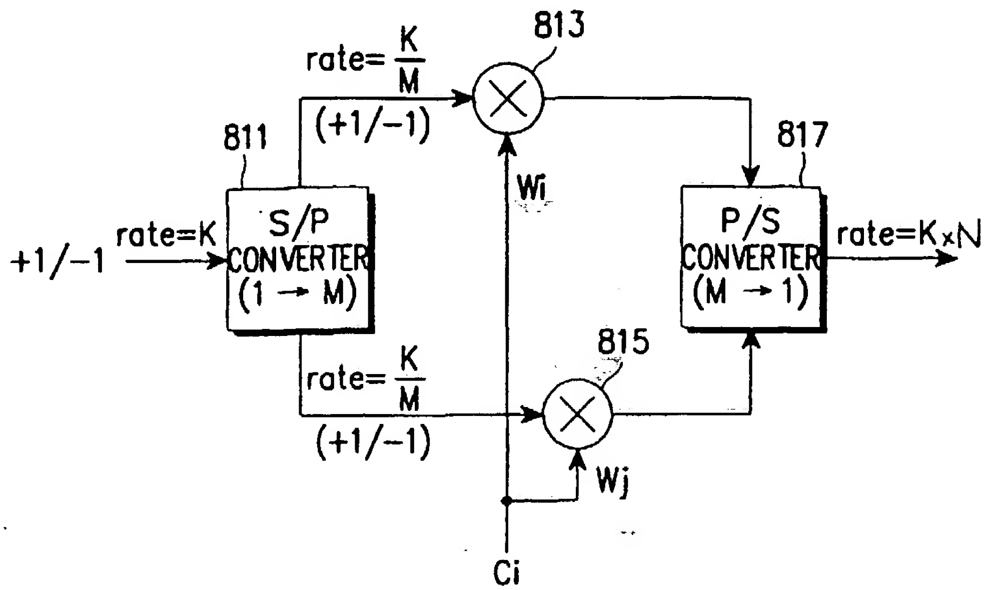

AUTO-CORRELATION
N
N: LEHGTH OF WALSH CODE
1
1/M
0
1 2 — M-1 M
DELAY TIME (CHIP)

FIG. 7B



813
rate= K/M
(+1/-1)
811
817
Wi
+1/-1
rate=K
S/P CONVERTER (1 → M)
P/S CONVERTER (M → 1)
rate=KxN
815
rate= K/M
(+1/-1)
Wj
Ci

FIG. 8

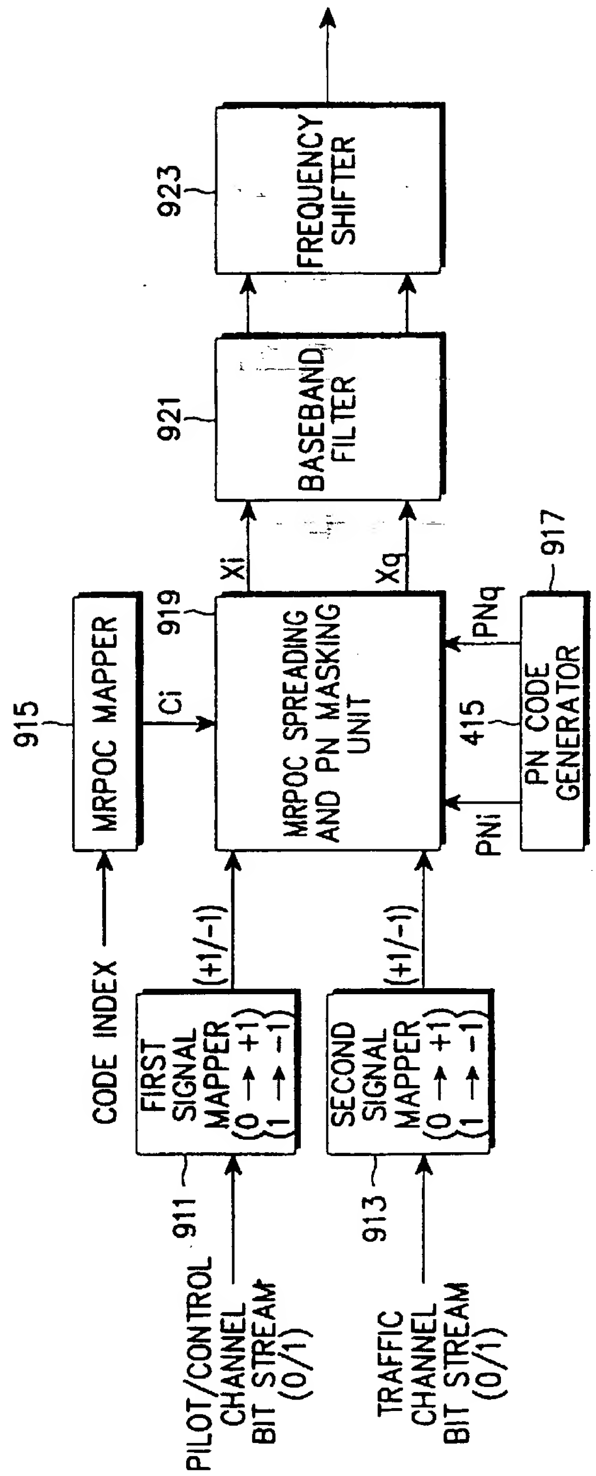

PILOT/CONTROL CHANNEL BIT STREAM (0/1)
911
FIRST SIGNAL MAPPER (0 → +1) (1 → −1)
(+1/-1)
TRAFFIC CHANNEL BIT STREAM (0/1)
913
SECOND SIGNAL MAPPER (0 → +1) (1 → −1)
(+1/-1)
CODE INDEX
915
MRPOC MAPPER
Ci
919
MRPOC SPREADING AND PN MASKING UNIT
PNi
PNq
415
PN CODE GENERATOR
917
Xi
Xq
921
BASEBAND FILTER
923
FREQUENCY SHIFTER

FIG. 9

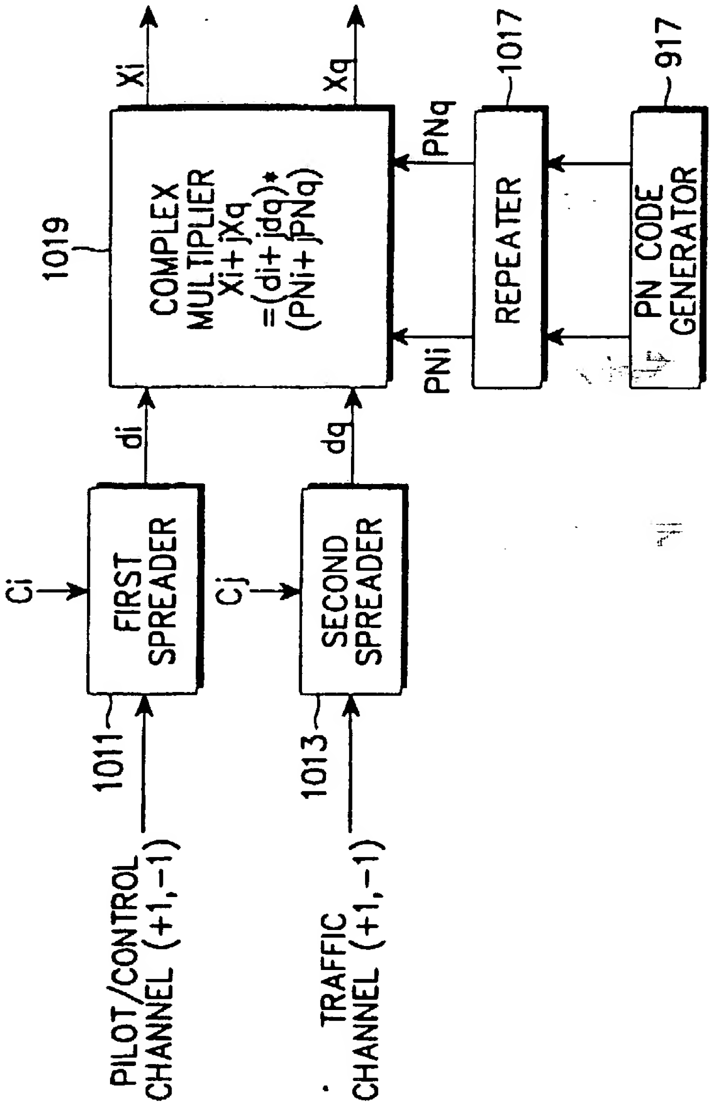

PILOT/CONTROL
CHANNEL (+1,-1)
TRAFFIC
CHANNEL (+1,-1)
1011
1013
Ci
Cj
FIRST
SPREADER
SECOND
SPREADER
di
dq
1019
COMPLEX
MULTIPLIER
Xi+jXq
=(di+jdq)*
(PNi+jPNq)
Xi
Xq
PNi
PNq
REPEATER
1017
PN CODE
GENERATOR
917

FIG. 10

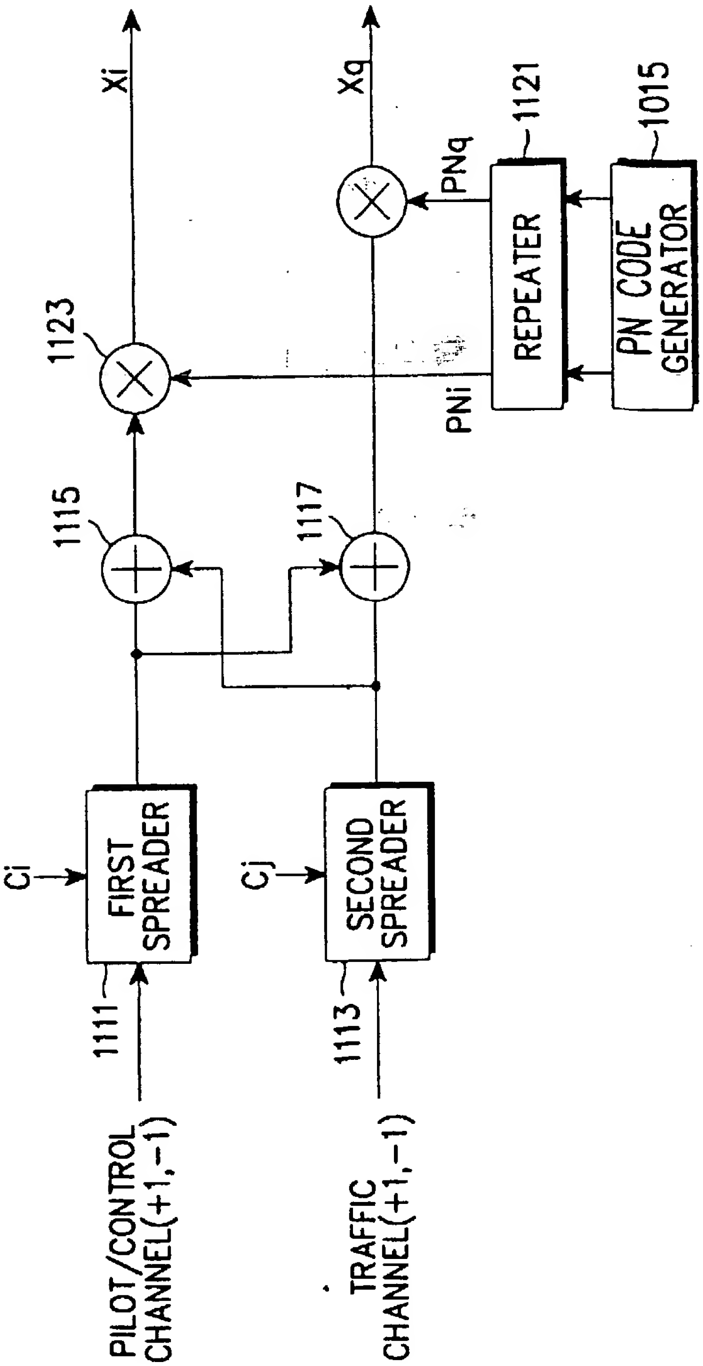

Xi
Xq
1123
1121
1015
PNq
REPEATER
PN CODE GENERATOR
PNi
1115
1117
Ci
FIRST SPREADER
Cj
SECOND SPREADER
1111
1113
PILOT/CONTROL CHANNEL(+1,−1)
TRAFFIC CHANNEL(+1,−1)

FIG. 11

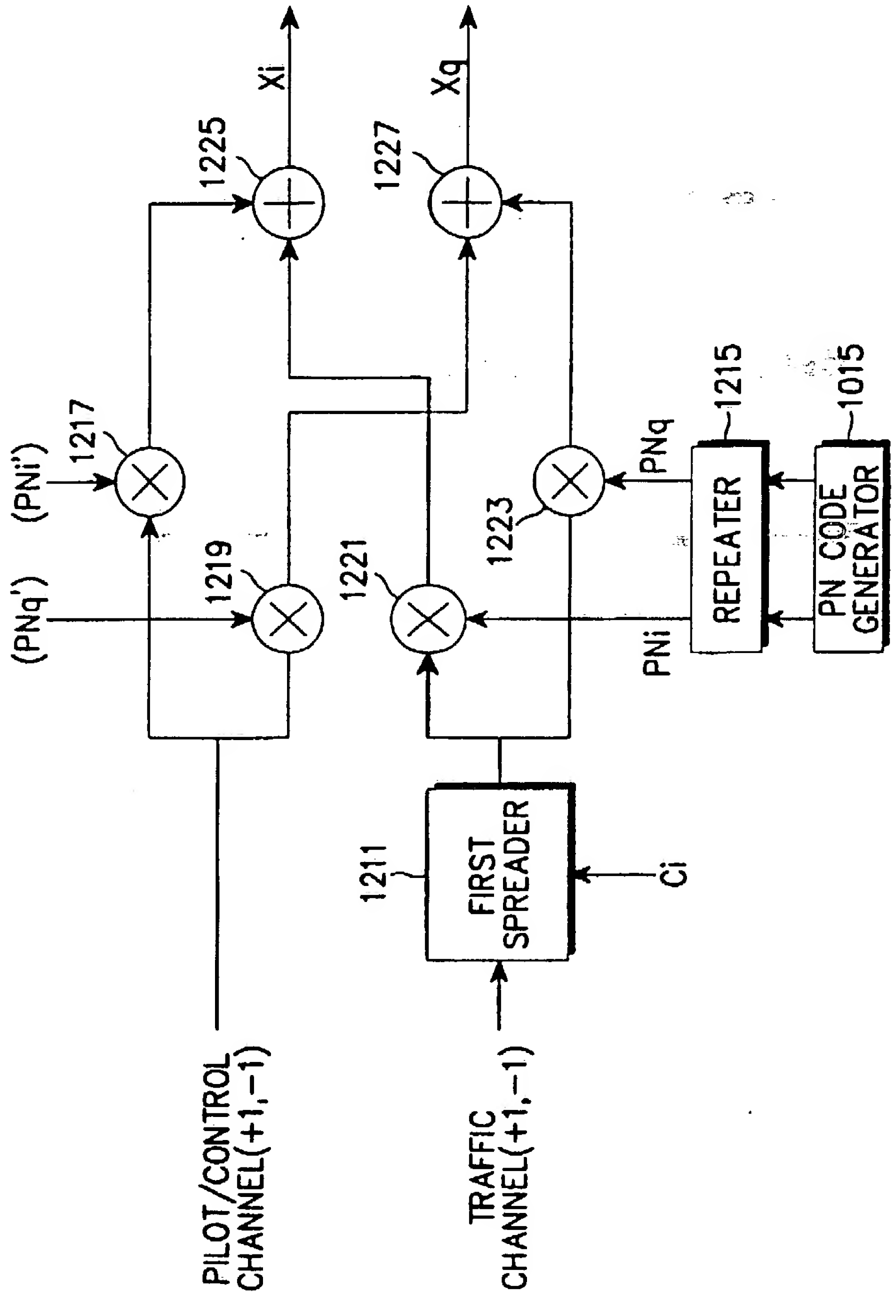
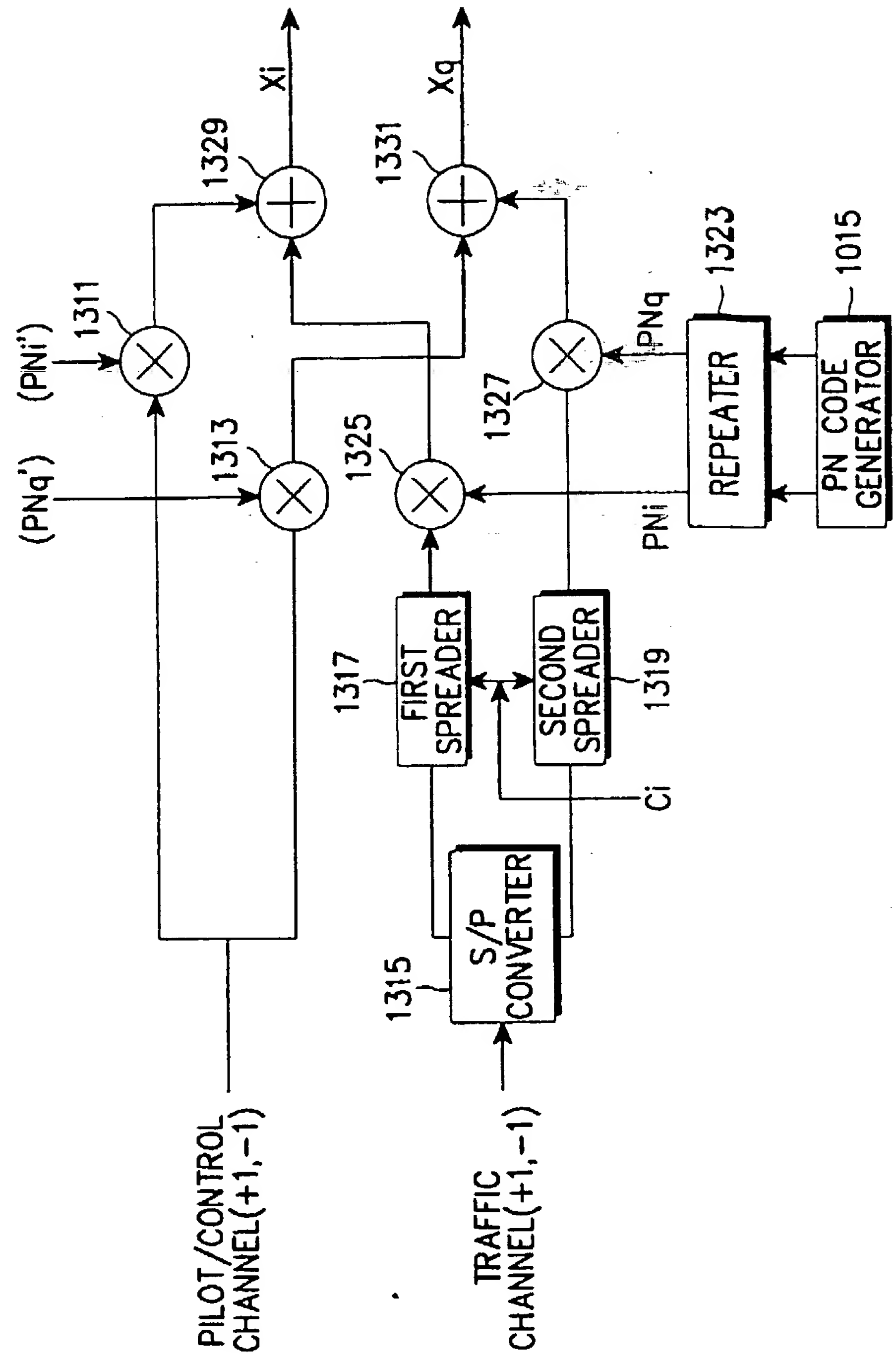

Xi
Xq
1225
1227
(PNi')
1217
(PNq')
1219
1221
1223
PNq
PNi
REPEATER
1215
PN CODE GENERATOR
1015
FIRST SPREADER
1211
Ci
PILOT/CONTROL CHANNEL(+1,−1)
TRAFFIC CHANNEL(+1,−1)

FIG. 12



(PNq')
(PNi')
1311
1313
1329
1331
Xi
Xq
1325
1327
PNq
PNi
REPEATER
1323
PN CODE GENERATOR
1015
FIRST SPREADER
1317
SECOND SPREADER
1319
Ci
S/P CONVERTER
1315
PILOT/CONTROL CHANNEL(+1,−1)
TRAFFIC CHANNEL(+1,−1)

FIG. 13

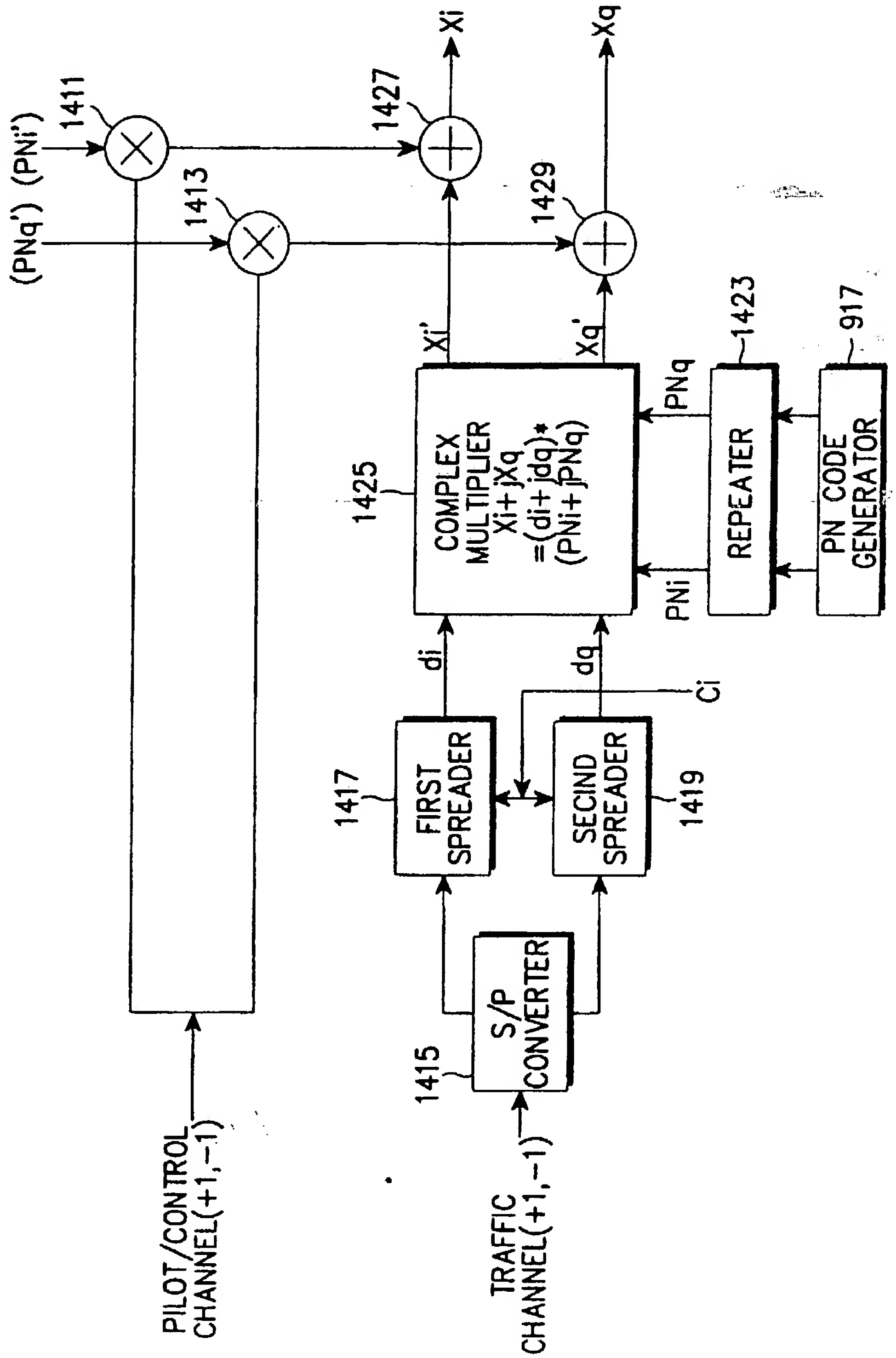

(PNq') (PNi')
1411
1413
1427
1429
Xi
Xq
Xi'
Xq'
1425
COMPLEX MULTIPLIER
Xi+jXq
=(di+jdq)*
(PNi+jPNq)
PNq
PNi
REPEATER
1423
PN CODE GENERATOR
917
di
dq
Ci
1417
FIRST SPREADER
SECIND SPREADER
1419
1415
S/P CONVERTER
PILOT/CONTROL CHANNEL(+1,-1)
TRAFFIC CHANNEL(+1,-1)

FIG. 14

Claims

1. A spread spectrum signal generating device for a transmitter of a mobile communication system using a plurality of channels comprising at least one of either constant bit rate and constant power level signals and at least one of either variable bit rate and variable power level signals, the device comprising:

   means for producing and outputting a time multiplexed channel by time multiplexing only the constant bit rate and constant power level signals for output on a first channel; and
   means for outputting at least one of the variable bit rate and variable power level signals on a second channel which is independent of the first channel.

2. A device as claimed in claim 1, further comprising encoders for orthogonally spreading the first channel and the second channel using respective orthogonal codes.

3. A device as claimed in any preceding claim, wherein the plurality of channels comprises a pilot channel signal, a control channel signal, a voice channel signal and a packet channel signal, and wherein means for producing a time multiplexed channel comprises:

   a multiplexer for time multiplexng the pilot channel signal and the control channel signal;
   a first orthogonal encoder for orthogonally spreading the output of the multiplexer using an orthogonal code;
   a second orthogonal encoder for orthogonally spreading the voice channel signal having a variable bit rate using an orthogonal code;
   a third orthogonal encoder for orthogonally spreading the packet channel signal having a variable bit rate using an orthogonal code;
   an IQ signal mapper for adding the outputs of the first and third orthogonal encoders, outputting the added signal on the first channel and outputting the output of the second orthogonal encoder on the second channel.

4. A device as claimed in claim 3, wherein the IQ mapper further comprises

   means for outputting the output of the second orthogonal encoder on the second channel in the presence of a voice channel signal; and means for outputting the outputs of the first and third orthogonal encoders on the first channel and the second channel respectively in the absence of a voice channel signal.

5. A device as claimed in either of claims 3 or 4, further comprising

   a PN spreader for spreading the first and second channels using PN codes to produce a spread spectrum signal; and
   means for outputting the spread spectrum signal.

6. A device as claimed in claim 5, wherein the PN spreader comprises

   means for complex-multiplying the first and second channels using PN codes.

7. A device as claimed in either of claims 5 or 6, further comprising

   a baseband modulator for baseband filtering the output of the PN spreader and modulating the filtered signal.

8. A device as claimed in claim 7, further comprising a frequency converter for upconverting the frequency of the output of the baseband modulator to a transmission frequency.

9. A device as claimed in any preceding claim, wherein the means for producing and outputting a time multiplexed channel comprises

   a plurality of rate adaptors for adjusting the rates of the at least one of either constant bit rate and constant power level signals and at least one of either variable bit rate and variable power level signals;
   a plurality of signal mappers for converting the Os and 1s received from the rate adaptors into +1s and -1s respectively;
   a plurality of channel amplitude controllers for multiplying the outputs of the signal mappers by corresponding

channel amplitude control values.

10. A device as claimed in any of claims 3 to 9, wherein the orthogonal codes comprises multipath resistant pseudo codes (MRPOCs).

11. A device as claimed in any preceding claim, whrein the time multiplexed first channel is output at a constant power level.

12. A device as claimed in any preceding claim, wherein the logical channel data generator and the pilot channel data are scrambled.

13. A spread spectrum signal generating method for a transmitter of a mobile communication system using a plurality of channels comprising at least one of either constant bit rate and constant power level signals and at least one of either variable bit rate and variable power level signals, the method comprising the steps of

producing and outputting a time multiplexed channel by time multiplexing only the constant bit rate and constant power level signals for output on a first channel; and
outputting at least one of the variable bit rate and variable power level signals on a second channel which is independent of the first channel.

14. A method as claimed in claim 13, further comprising the step of

orthogonally spreading the first channel and the second channel using respective orthogonal codes.

15. A method as claimed in either of claims 13 or 14,
wherein the plurality of channels comprises a pilot channel signal, a control channel signal, a voice channel signal and a packet channel signal, and wherein the step of producing a time multiplexed channel comprises the steps of

time multiplexng the pilot channel signal and the control channel signal;
orthogonally spreading, using a first orthogonal encoder, the output of the multiplexer using an orthogonal code;
orthogonally spreading, using a second orthogonal encoder, the voice channel signal having a variable bit rate using an orthogonal code;
orthogonally spreading, using a third orthogonal encoder, the packet channel signal having a variable bit rate using an orthogonal code;
adding the outputs of the first and third orthogonal encoders, outputting the added signal on the first channel and outputting the output of the second orthogonal encoder on the second channel.

16. A method as claimed in claim 15, further comprising the steps of

outputting the output of the second orthogonal encoder on the second channel in the presence of a voice channel signal; and
outputting the outputs of the first and third orthogonal encoders on the first channel and the second channel respectively in the absence of a voice channel signal.

17. A method as claimed in either of claims 15 or 16, further comprising the steps of

spreading, using a PN spreader, the first and second channels using PN codes to produce a spread spectrum signal; and
outputting the spread spectrum signal.

18. A method as claimed in claim 17, wherein the step of spreading comprises the step

complex-multiplying the first and second channels using PN codes.

19. A method as claimed in either of claims 17 or 18, further comprising the steps of

baseband filtering, using a baseband modulator, the output of the PN spreader; and

modulating the filtered signal.

20. A method as claimed in claim 19, further comprising the step of

upconverting, using a frequency converter, the frequency of the output of the baseband modulator to a transmission frequency.

21. A method as claimed in any of claims 13 to 20; wherein the step of producing and outputting a time multiplexed channel comprises the steps of

adjusting, using a plurality of rate adaptors, the rates of the at least one of either constant bit rate and constant power level signals and at least one of either variable bit rate and variable power level signals;
converting, using a plurality of signal mappers, the 0s and 1s received from the rate adaptors into +1s and -1s respectively;
multiplying, using a plurality of channel amplitude controller, the outputs of the signal mappers by corresponding channel amplitude control values.

22. A method as claimed in any of claims 13 to 21, wherein the orthogonal codes comprises multipath resistant pseudo codes (MRPOCs).

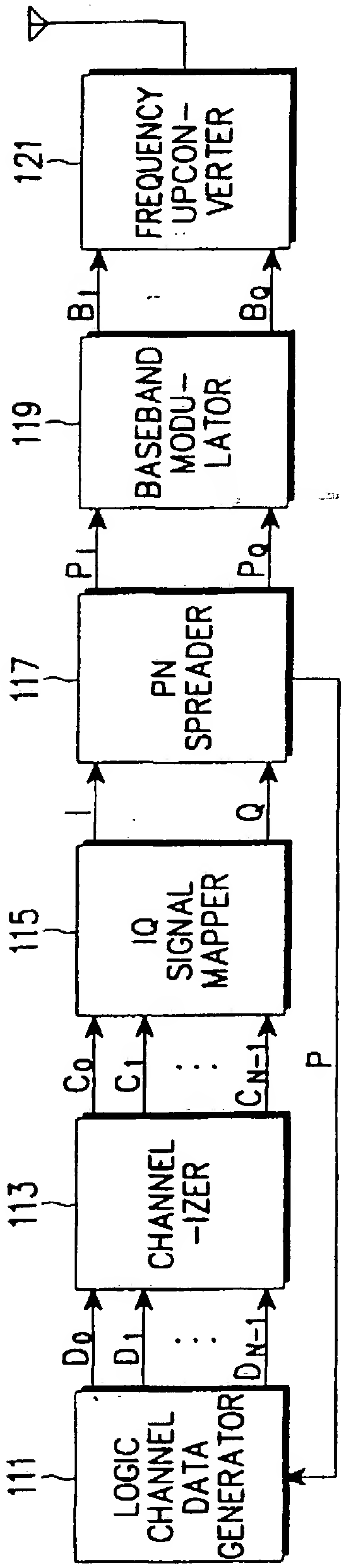

111
LOGIC CHANNEL DATA GENERATOR
113
CHANNEL -IZER
115
IQ SIGNAL MAPPER
117
PN SPREADER
119
BASEBAND MODU- LATOR
121
FREQUENCY UPCON- VERTER
D_0
D_1
D_{N-1}
C_0
C_1
C_{N-1}
I
Q
P_I
P_Q
B_I
B_Q
P

FIG. 1

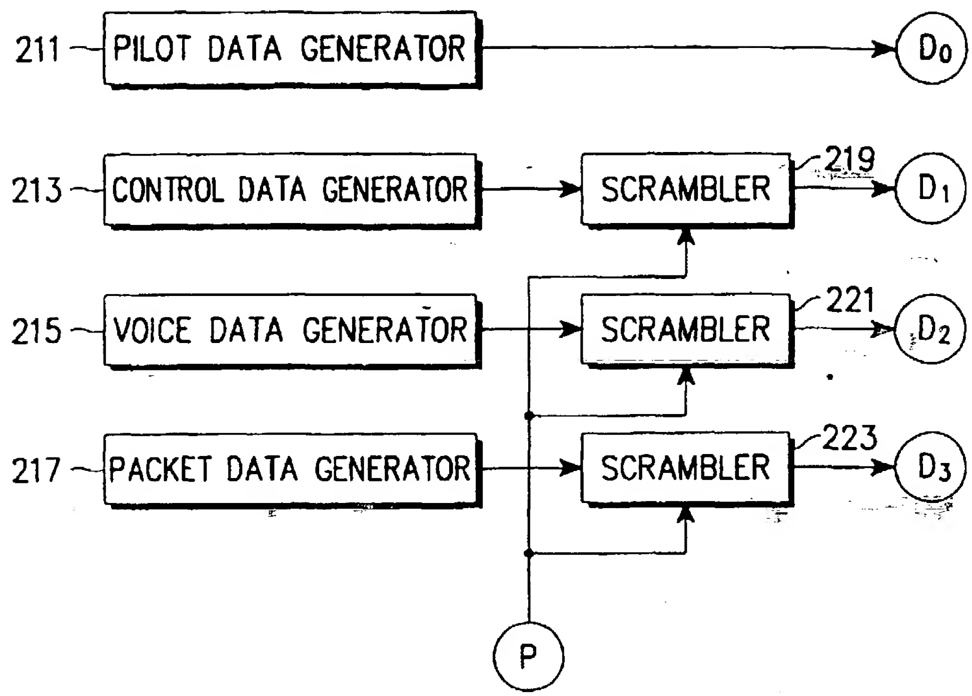

211
PILOT DATA GENERATOR
D0
213
CONTROL DATA GENERATOR
SCRAMBLER
219
D1
215
VOICE DATA GENERATOR
SCRAMBLER
221
D2
217
PACKET DATA GENERATOR
SCRAMBLER
223
D3
P

FIG. 2A

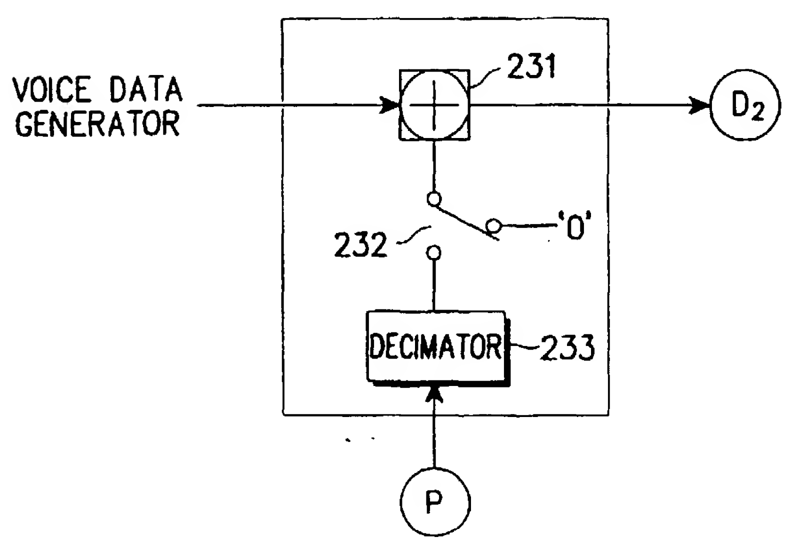

VOICE DATA GENERATOR
231
D2
'0'
232
DECIMATOR
233
P

FIG. 2B

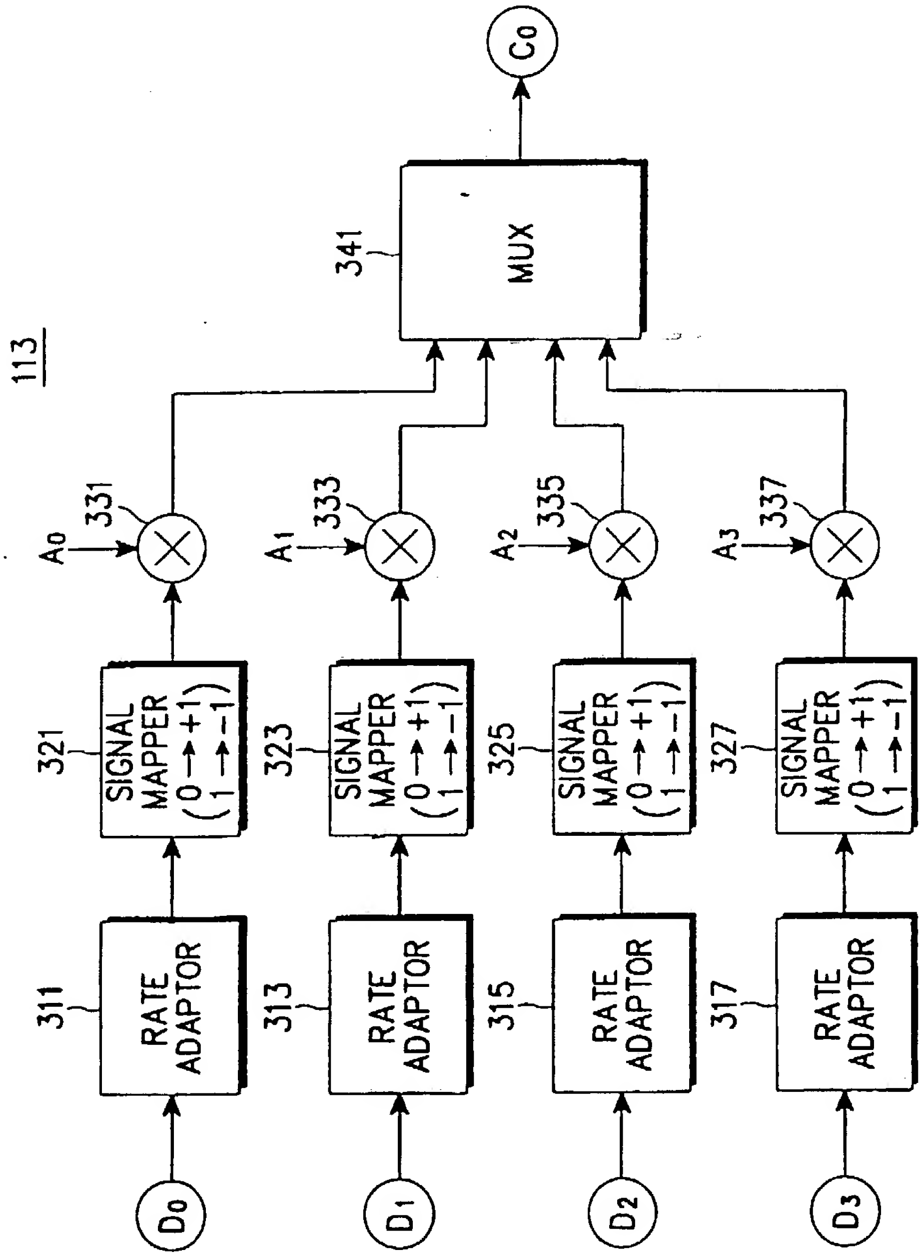

113
D0
D1
D2
D3
311
313
315
317
RATE ADAPTOR
RATE ADAPTOR
RATE ADAPTOR
RATE ADAPTOR
321
323
325
327
SIGNAL MAPPER (0→+1) (1→-1)
SIGNAL MAPPER (0→+1) (1→-1)
SIGNAL MAPPER (0→+1) (1→-1)
SIGNAL MAPPER (0→+1) (1→-1)
A0
A1
A2
A3
331
333
335
337
341
MUX
C0

FIG. 3A

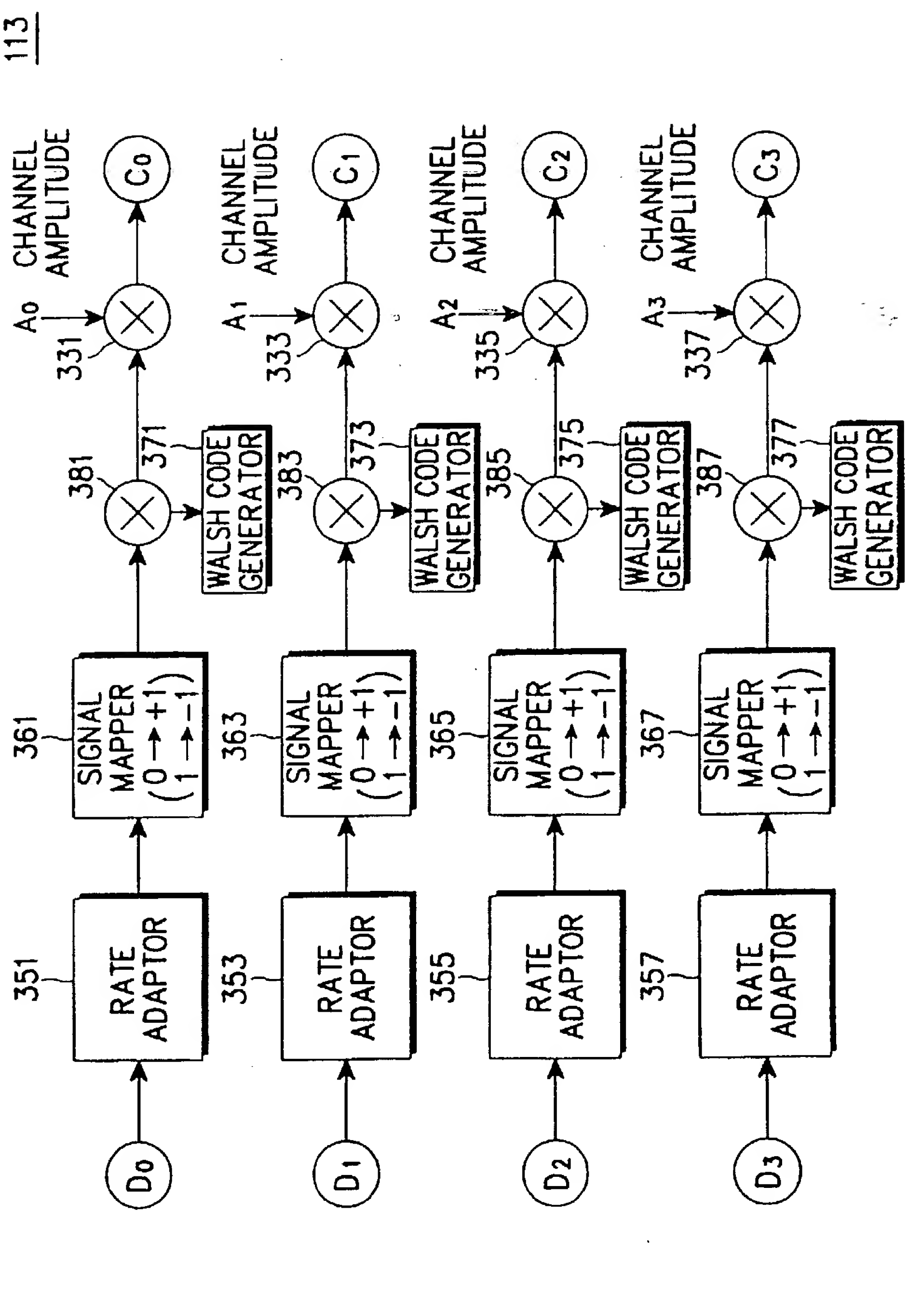

113
CHANNEL AMPLITUDE
A0
A1
A2
A3
C0
C1
C2
C3
D0
D1
D2
D3
331
333
335
337
381
383
385
387
371
373
375
377
WALSH CODE GENERATOR
WALSH CODE GENERATOR
WALSH CODE GENERATOR
WALSH CODE GENERATOR
361
363
365
367
SIGNAL MAPPER (0→+1) (1→−1)
SIGNAL MAPPER (0→+1) (1→−1)
SIGNAL MAPPER (0→+1) (1→−1)
SIGNAL MAPPER (0→+1) (1→−1)
351
353
355
357
RATE ADAPTOR
RATE ADAPTOR
RATE ADAPTOR
RATE ADAPTOR

FIG. 3B

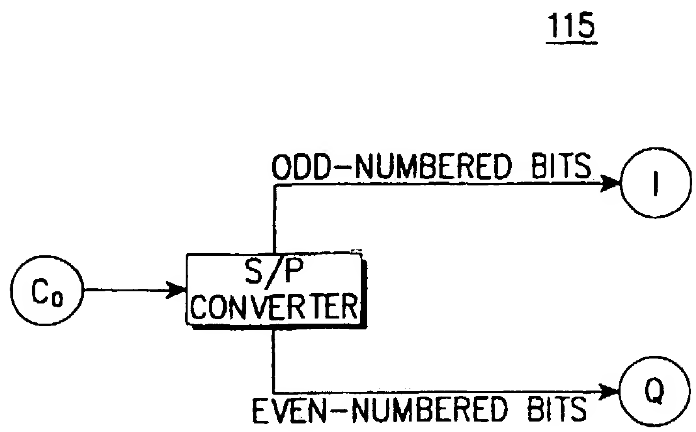

115
ODD-NUMBERED BITS
I
C_0
S/P
CONVERTER
EVEN-NUMBERED BITS
Q

FIG. 4A

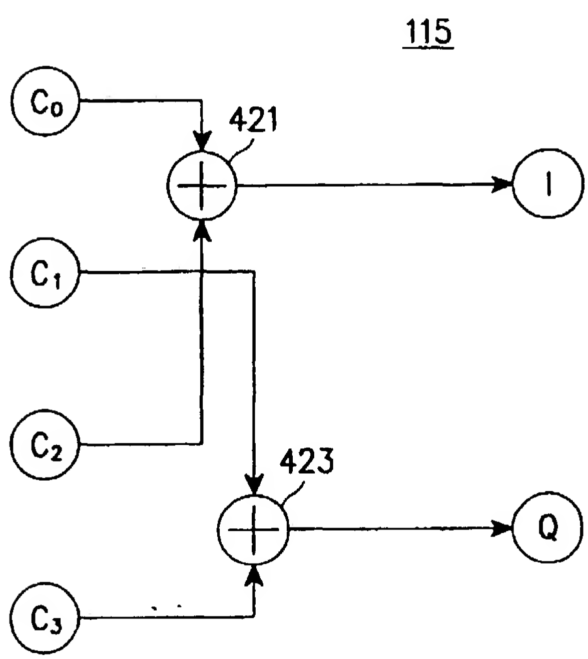

115
C_0
421
I
C_1
C_2
423
Q
C_3

FIG. 4B

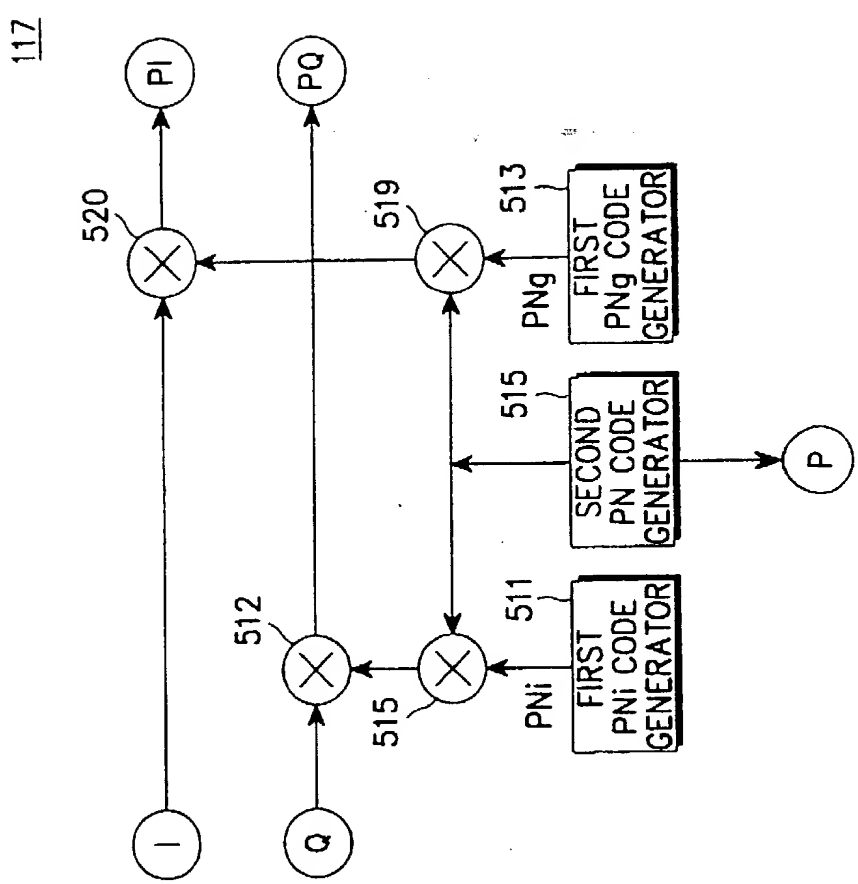

117
I
Q
PI
PQ
520
512
519
515
511
513
515
PNi
PNg
FIRST PNi CODE GENERATOR
SECOND PN CODE GENERATOR
FIRST PNg CODE GENERATOR
P

FIG. 5A

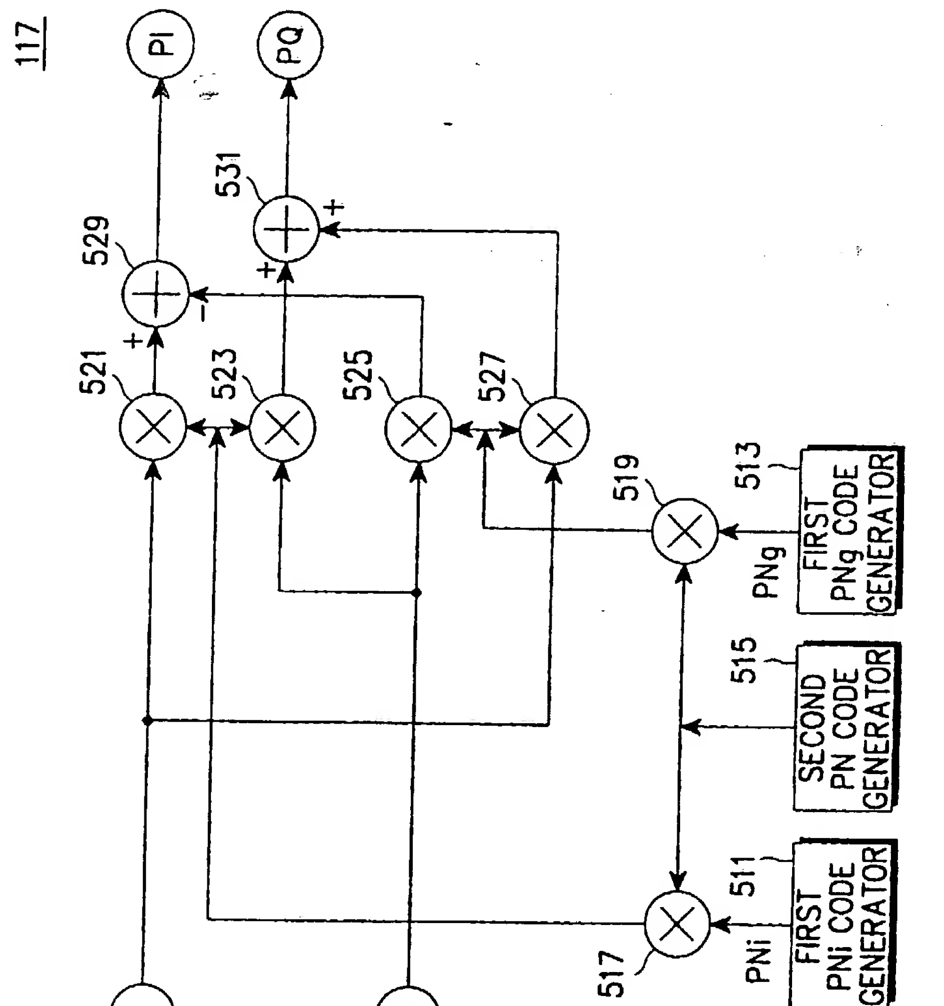

117
I
Q
PI
PQ
521
523
525
527
529
531
517
519
511
513
515
PNi
PNg
FIRST
PNi CODE
GENERATOR
SECOND
PN CODE
GENERATOR
FIRST
PNg CODE
GENERATOR

FIG. 5B

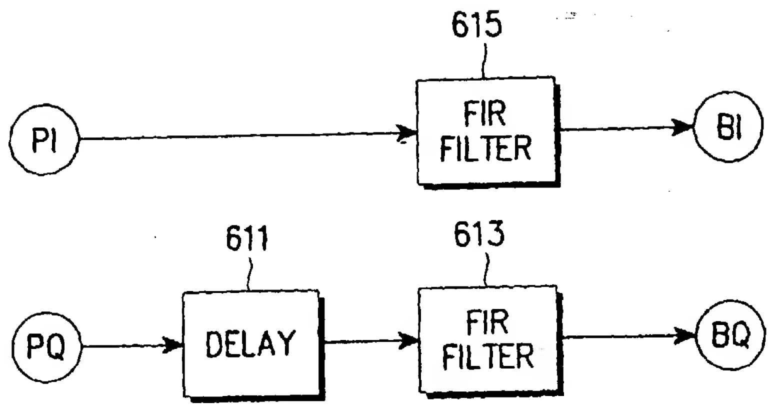


FIG. 6

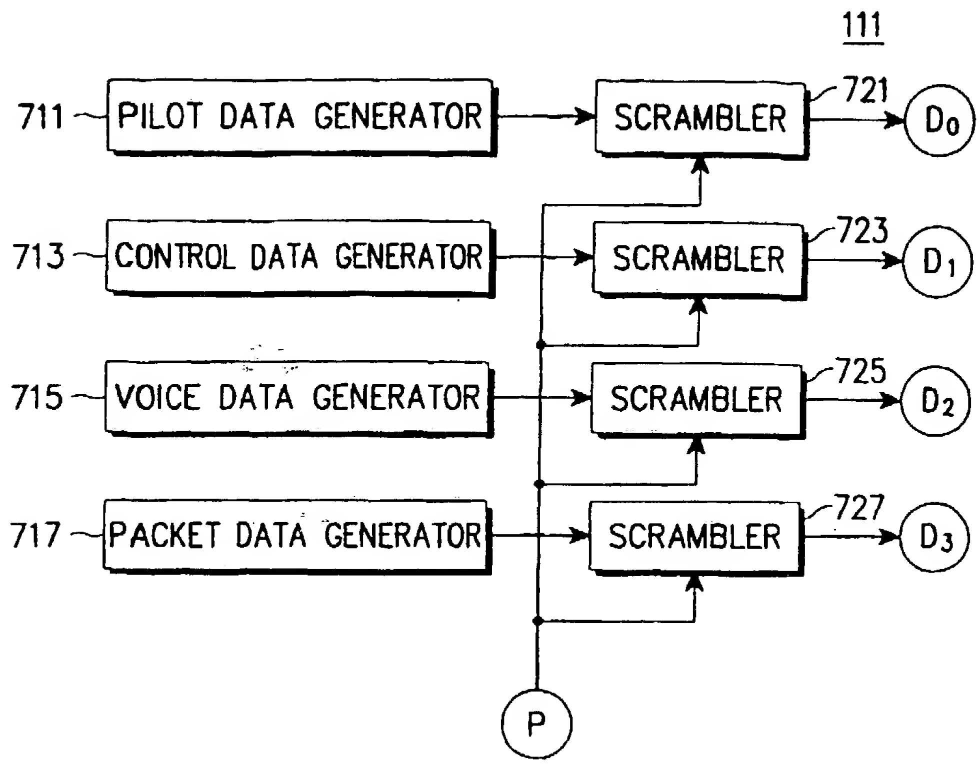

111
711
PILOT DATA GENERATOR
SCRAMBLER
721
D_0
713
CONTROL DATA GENERATOR
SCRAMBLER
723
D_1
715
VOICE DATA GENERATOR
SCRAMBLER
725
D_2
717
PACKET DATA GENERATOR
SCRAMBLER
727
D_3
P

FIG. 7A

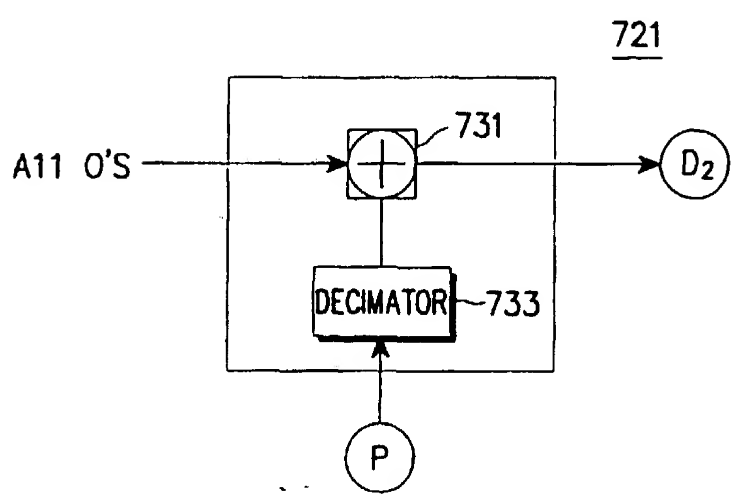

721
A11 O'S
731
D_2
DECIMATOR
733
P

FIG. 7B

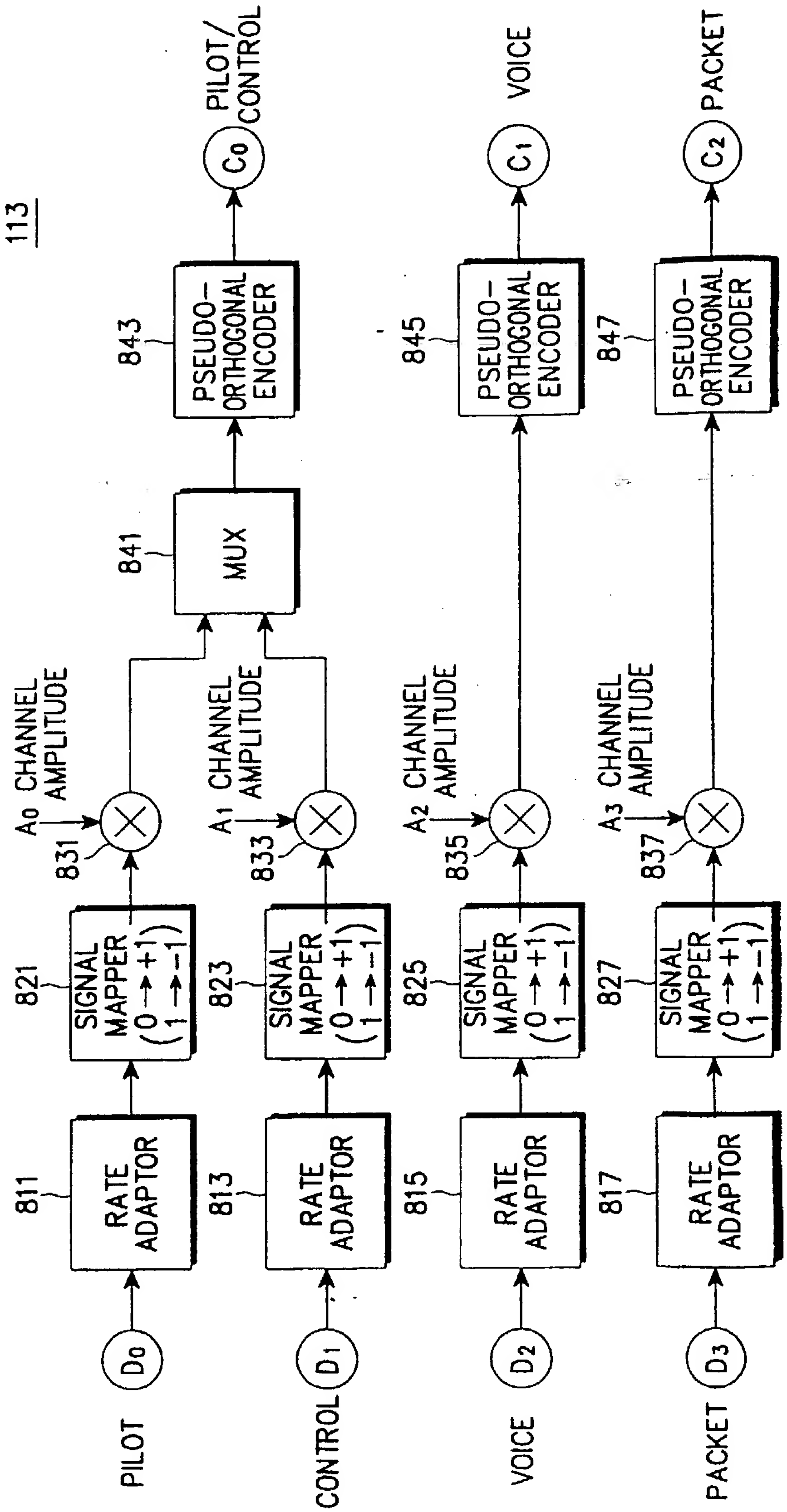

113
PILOT
CONTROL
VOICE
PACKET
D0
D1
D2
D3
811
813
815
817
RATE ADAPTOR
821
823
825
827
SIGNAL MAPPER (0→+1) (1→−1)
831
833
835
837
A0 CHANNEL AMPLITUDE
A1 CHANNEL AMPLITUDE
A2 CHANNEL AMPLITUDE
A3 CHANNEL AMPLITUDE
841
MUX
843
845
847
PSEUDO-ORTHOGONAL ENCODER
C0
C1
C2
PILOT/CONTROL
VOICE
PACKET

FIG. 8

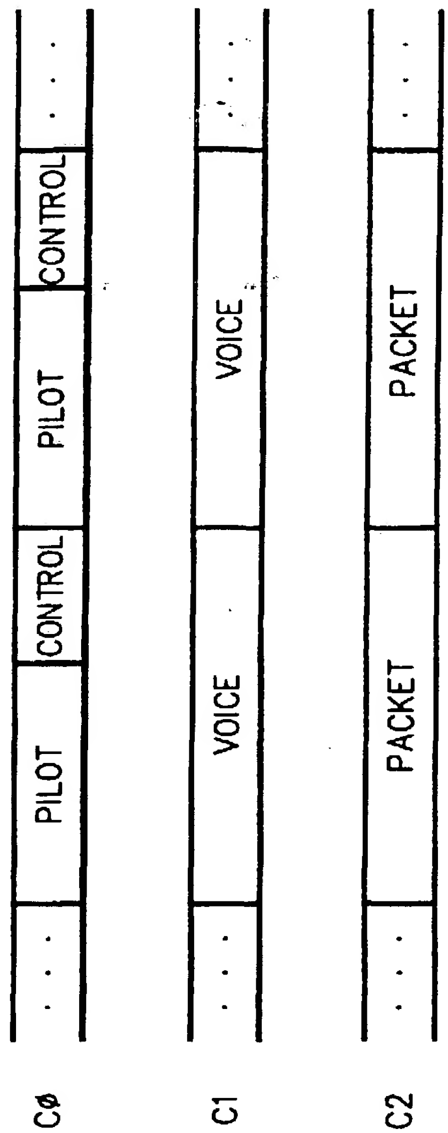

CØ
C1
C2
PILOT
CONTROL
PILOT
CONTROL
VOICE
VOICE
PACKET
PACKET

FIG. 9

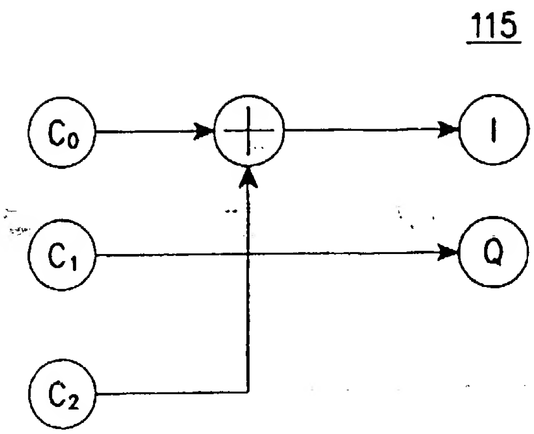


FIG. 10A

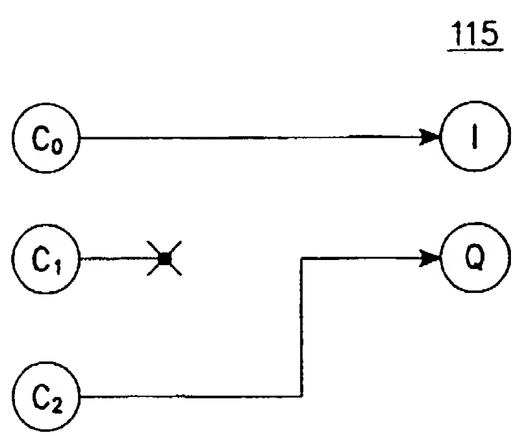


FIG. 10B

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